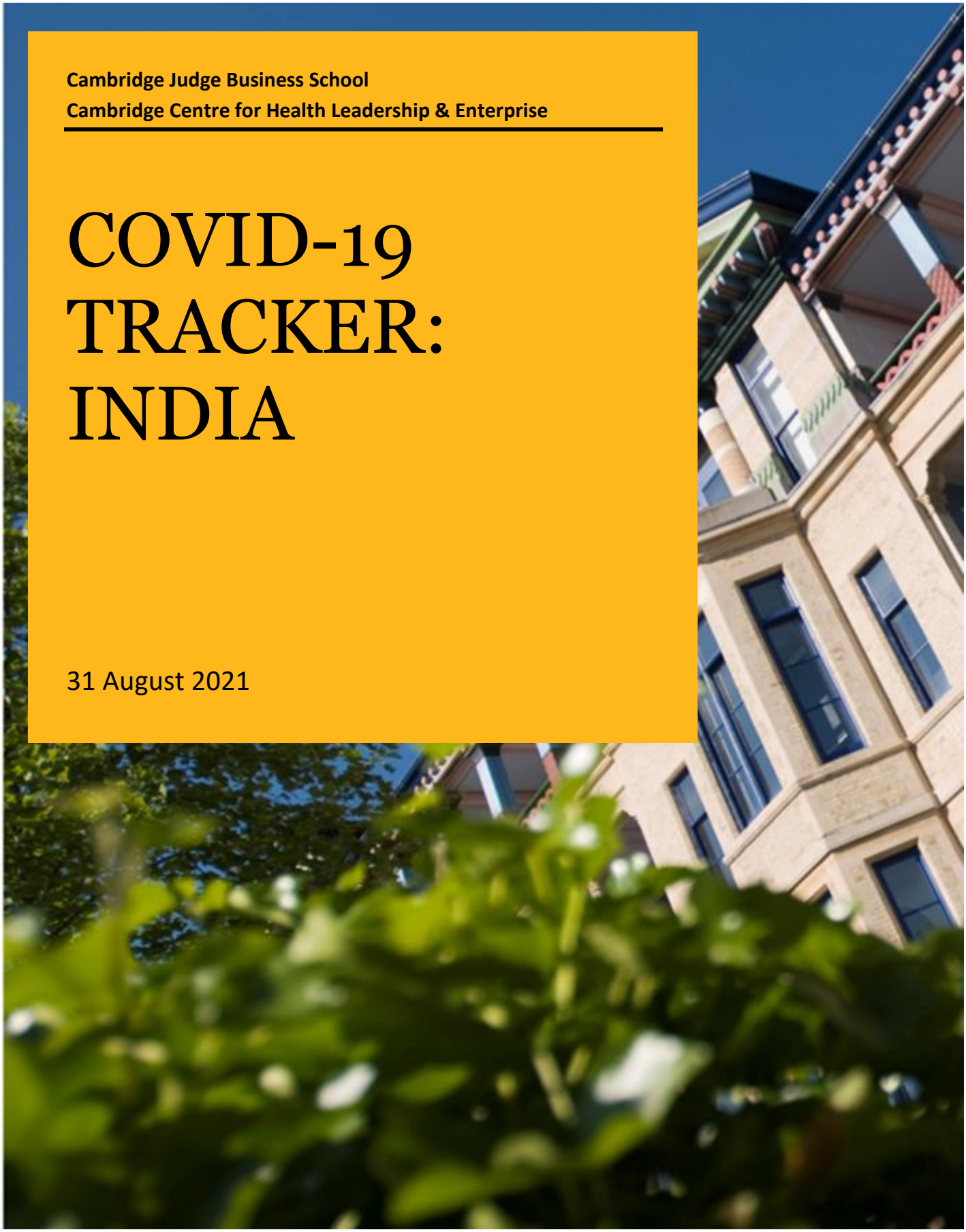
Cambridge Judge Business School
Cambridge Centre for Health Leadership & Enterprise

COVID-19 TRACKER: INDIA

31 August 2021



Centre for Health Leadership & Enterprise
UNIVERSITY OF CAMBRIDGE Judge Business School
HSTP Health Systems Transformation Platform
National Institute of Economic and Social Research

This tracker[1] has been developed by researchers at Cambridge Judge Business School and National Institute of Economic and Social Research, working with Health Systems Transformation Platform in India, as part of a pandemic monitoring series devoted to India and its states and union territories. It provides short term forecasts of the trajectory of the pandemic, identifying states and union territories that are at risk of increases in infection incidence. The forecasts are based on a structural time series model that uses historical data in estimation but adapts to the trend emerging in the most recent period. The model is described in Harvey and Kattuman (2021) "Time series models based on growth curves with applications to forecasting coronavirus". *Harvard Data Science Review*, Special issue 1 - COVID -19.

The effective reproduction number (R_t) for India as a whole has increased to 1.12 as of 31 August. The trend value of the daily growth rate of new cases increased to 2.8%. The trend value of reported cases are forecast to rise to 66,000 per day by 14 September. With Kerala accounting for 70% of daily cases in the country, the epidemic curve in India is driven at present by the epidemic curve in Kerala.

While nine states / union territories have seen increases in infection over the past week, Kerala stands out conspicuously due to the acute increase in cases that followed recent festivities that summitted on 21 August with the Onam harvest festival. The downward drift in the daily growth rate of cases earlier that was partly attributable to reduced testing over the festival period, turned around and soared to peak at 6.9% in trend value terms on 29 August.

Encouragingly, aided by recent post-festival containment measures and some degree of social restraint, the daily growth rate has turned around again and begun to decline in Kerala. Despite a sharp rise in targeted testing the daily growth rate has dropped to a trend value of 5.1% as of 31 August. Correspondingly the daily growth for India has reversed its earlier rise and dropped from 4% to 2.8% in the last two days. An augmented containment policy should help reinforce the decline in the rate of growth over the coming days in Kerala, and thus in India.

The longer term prospect the world over, as per current epidemiological opinion, is of a slow transition to endemicity rather than of complete elimination of COVID-19.

[1] CJBS COVID-19 Tracker for India can be accessed at: www.jbs.cam.ac.uk/covid-india
The companion spreadsheet contains all the estimates and forecasts.

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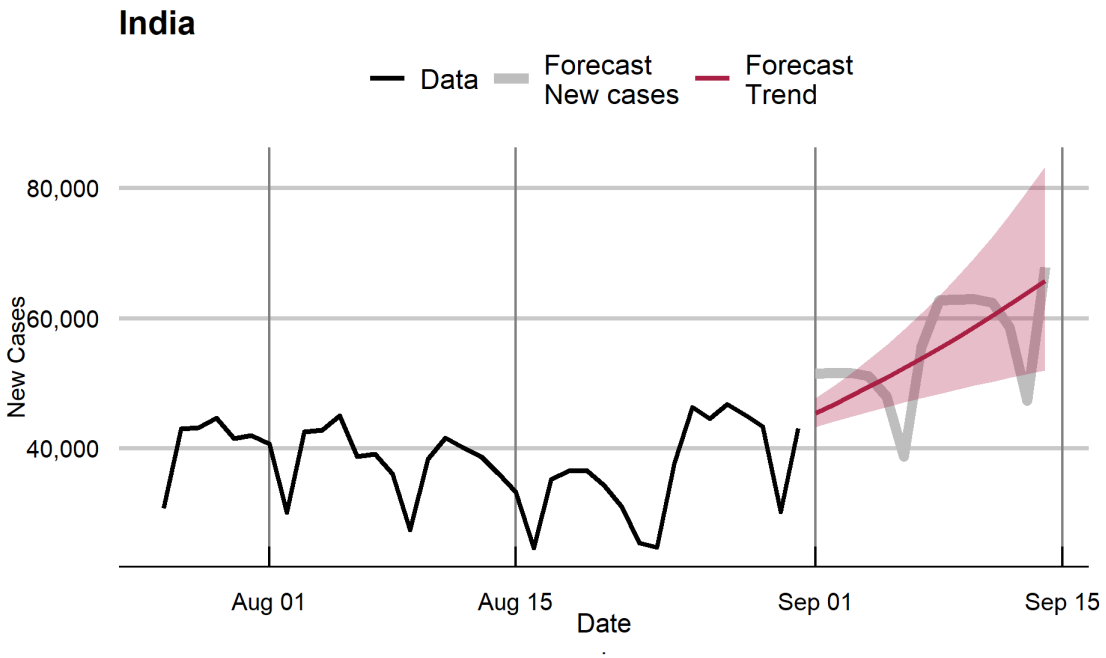
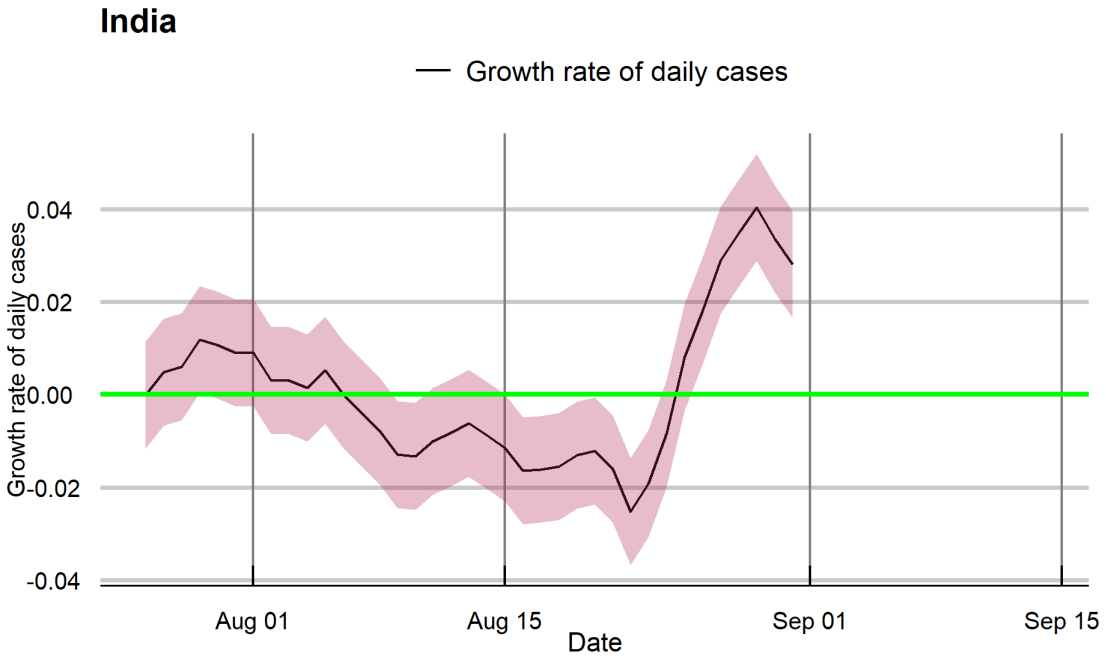
Daily Covid-19 cases in India: Forecast

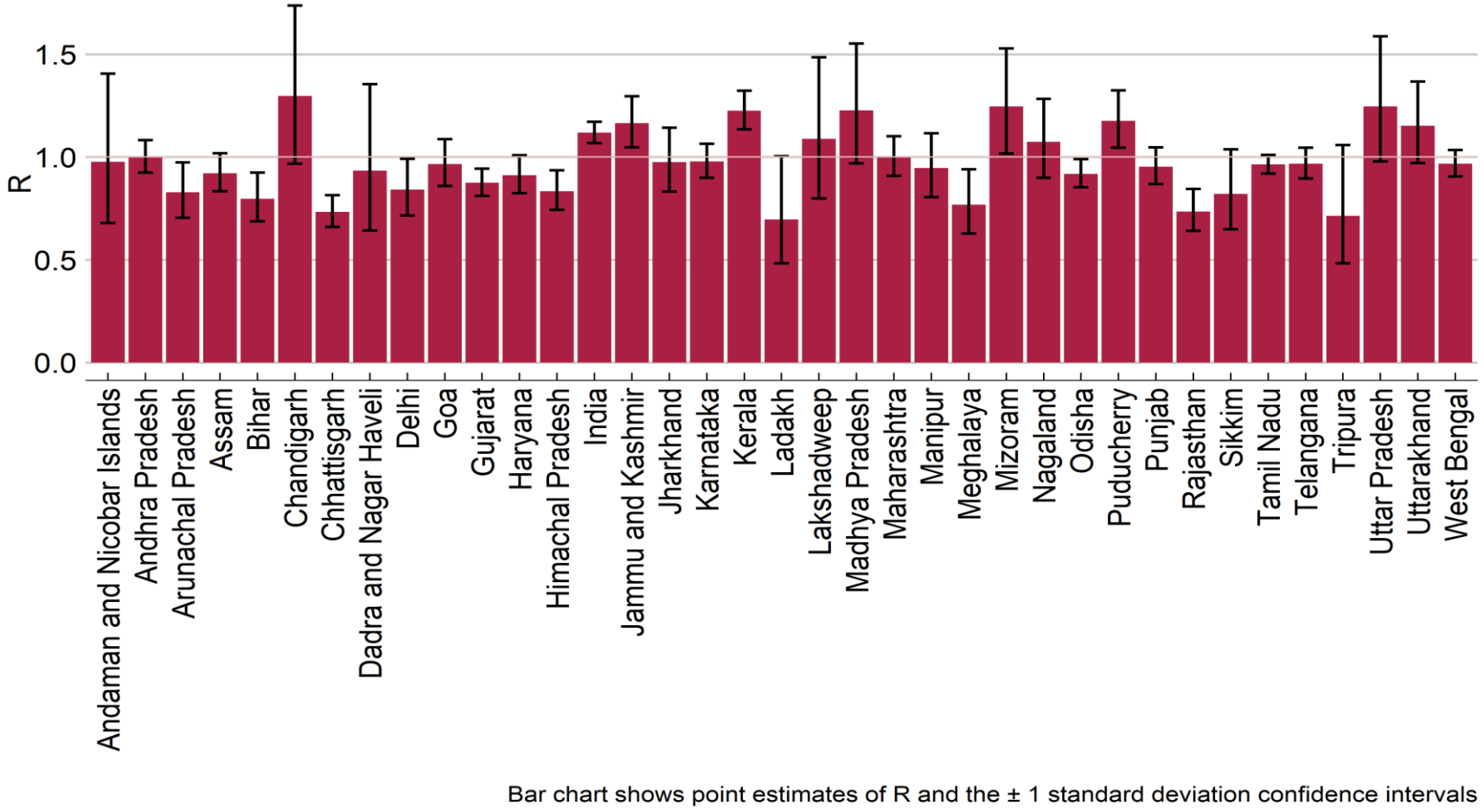
Forecasts of daily new cases for the period 1 to 14 September 2021, based on data till 31 August 2021. The trend value of new COVID-19 cases is likely to be just under 66,000 per day by 14 September 2021.



The filtered trend in the growth rate of daily new cases was 2.8% as on 31 August 2021.

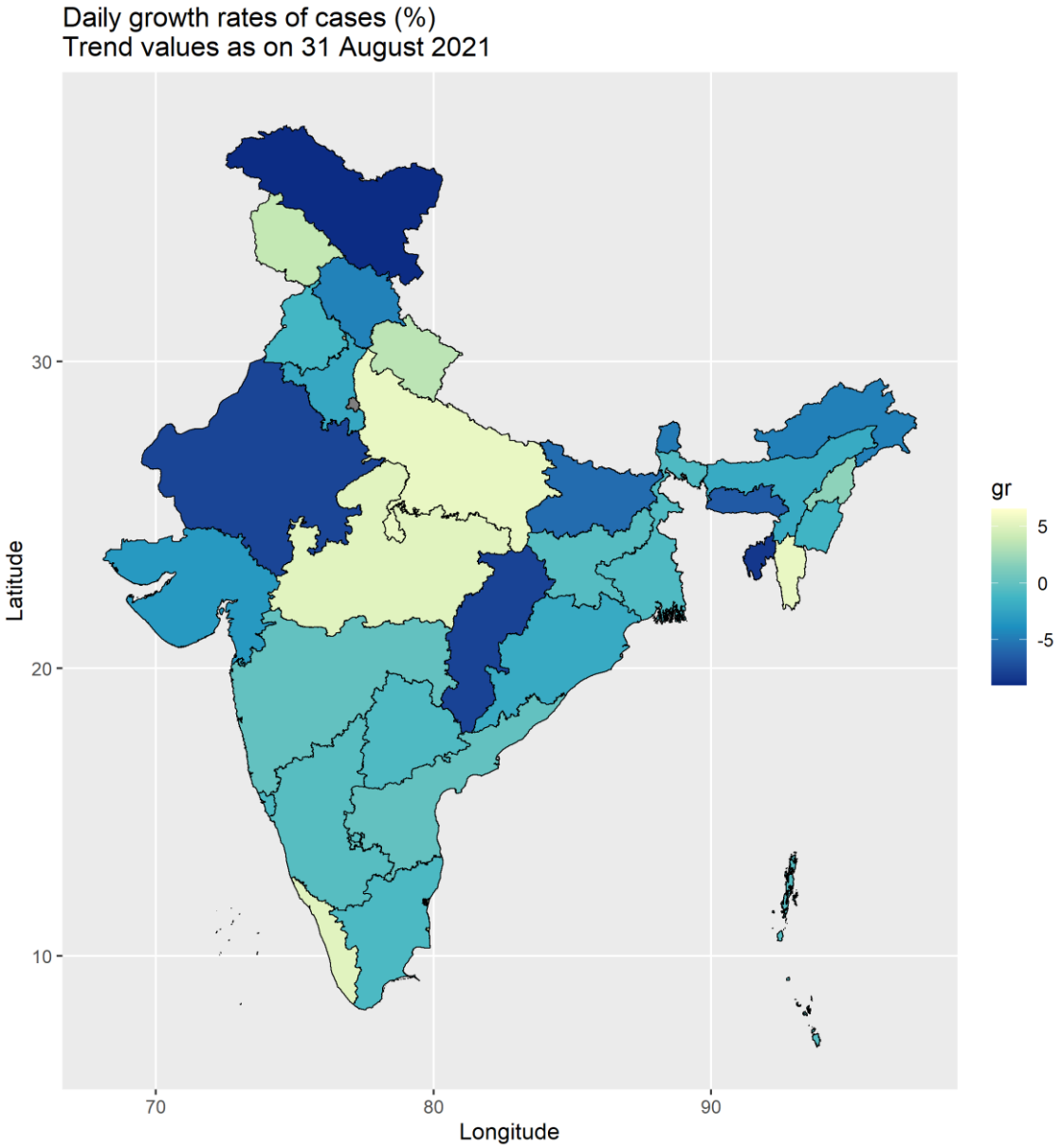


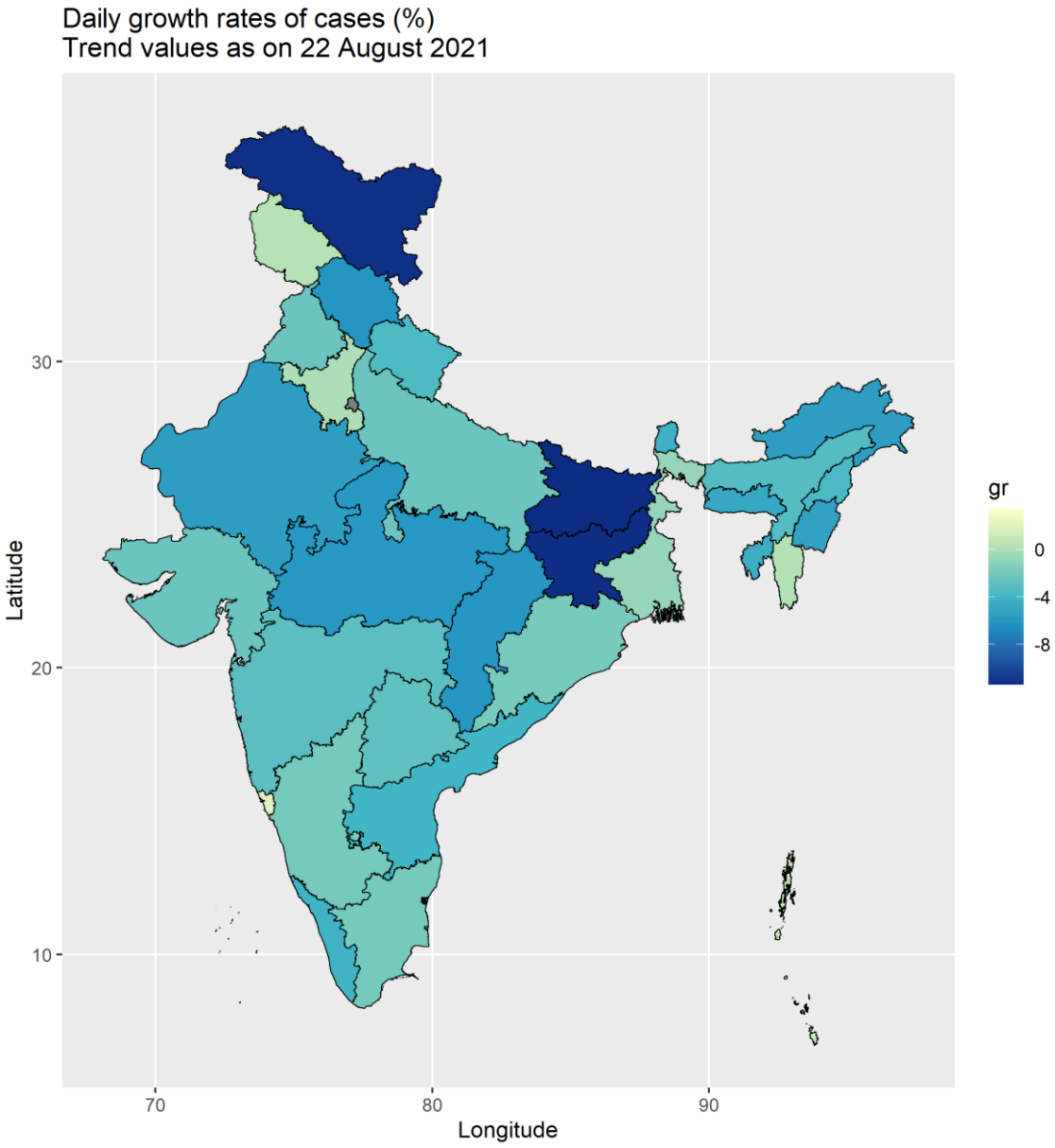
R_t: 31 August 2021



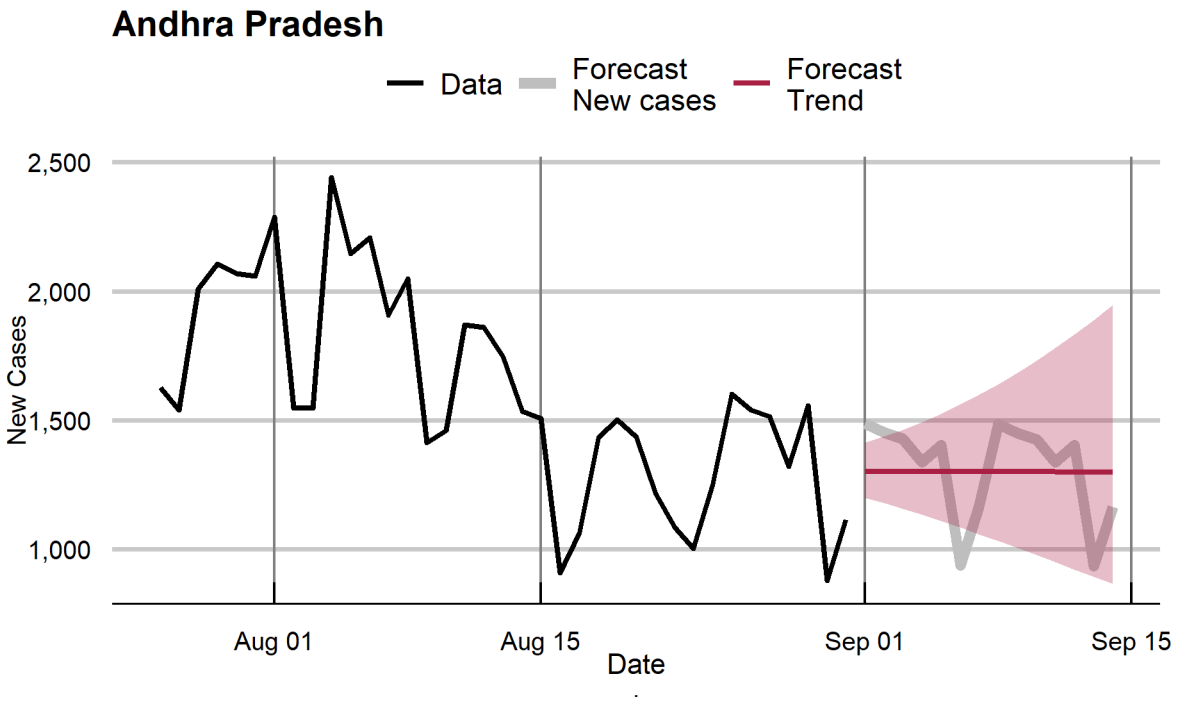
Bar chart shows point estimates of R and the ± 1 standard deviation confidence intervals

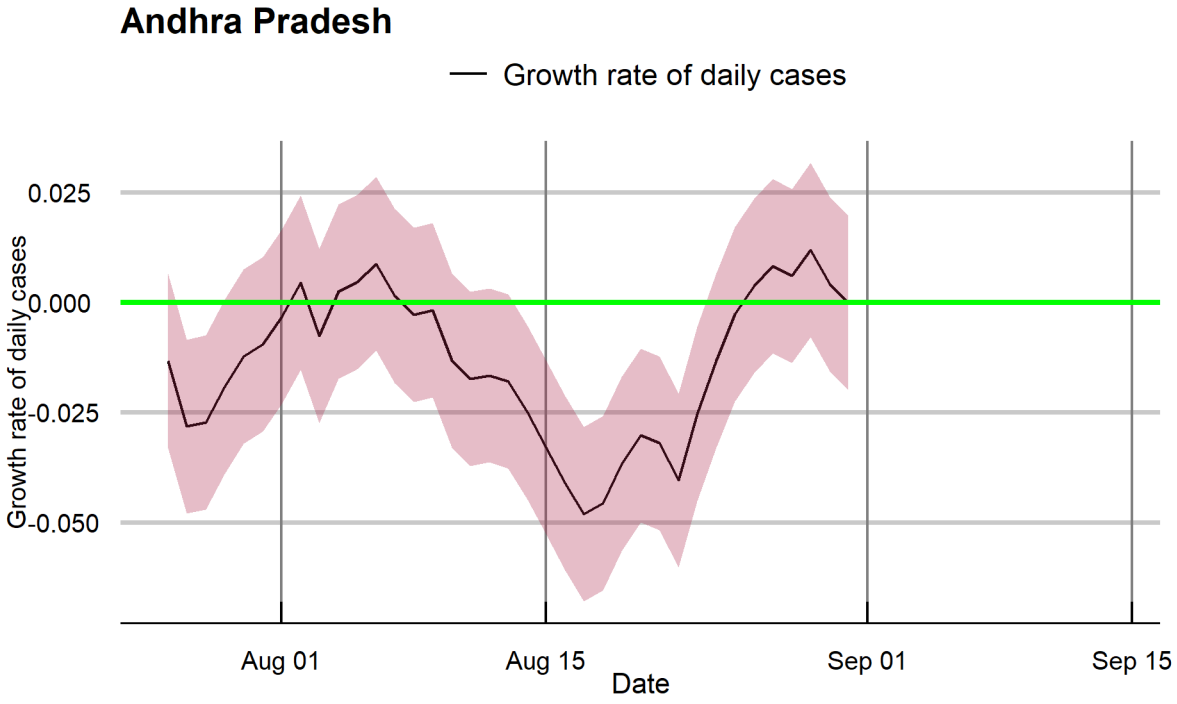
Note: Small daily numbers (less than 30) currently for Andaman and Nicobar Islands, Bihar, Chandigarh, Dadra and Nagar Haveli, Delhi, Gujarat, Haryana, Ladakh, Lakshadweep, Jharkhand, Madhya Pradesh, Rajasthan and Uttarakhand make their forecasts and estimates less precise.

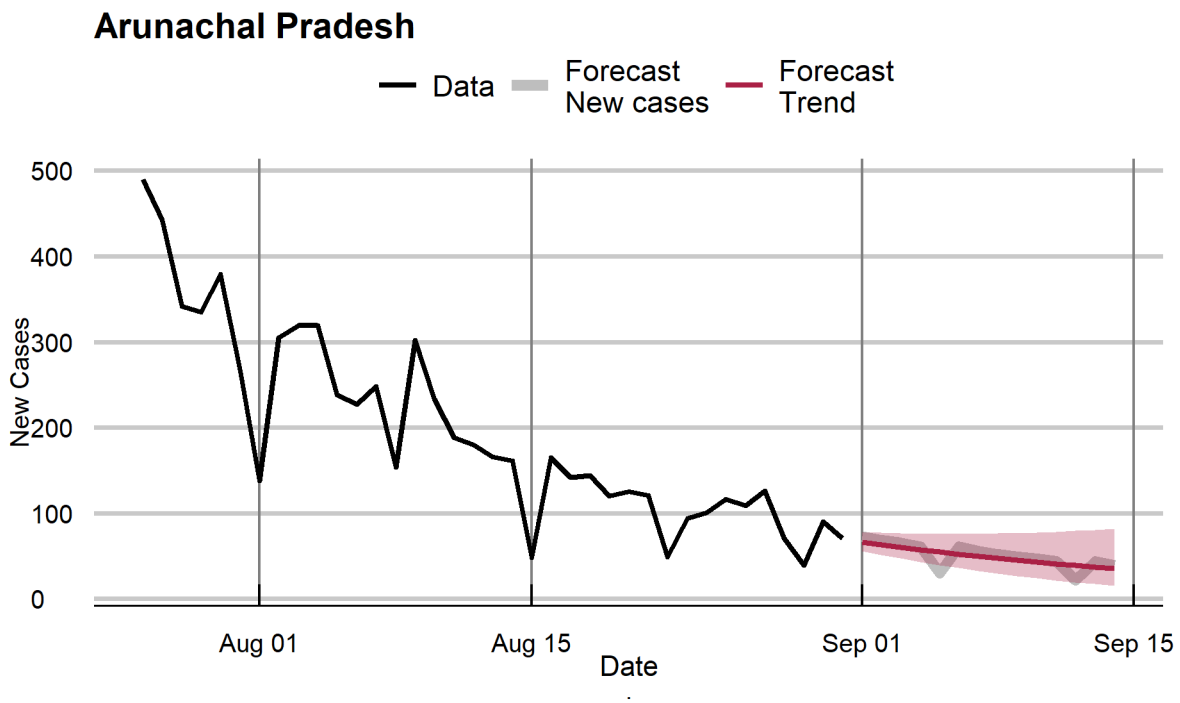

Daily growth rates of cases (%)
Trend values as on 31 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
5
0
-5

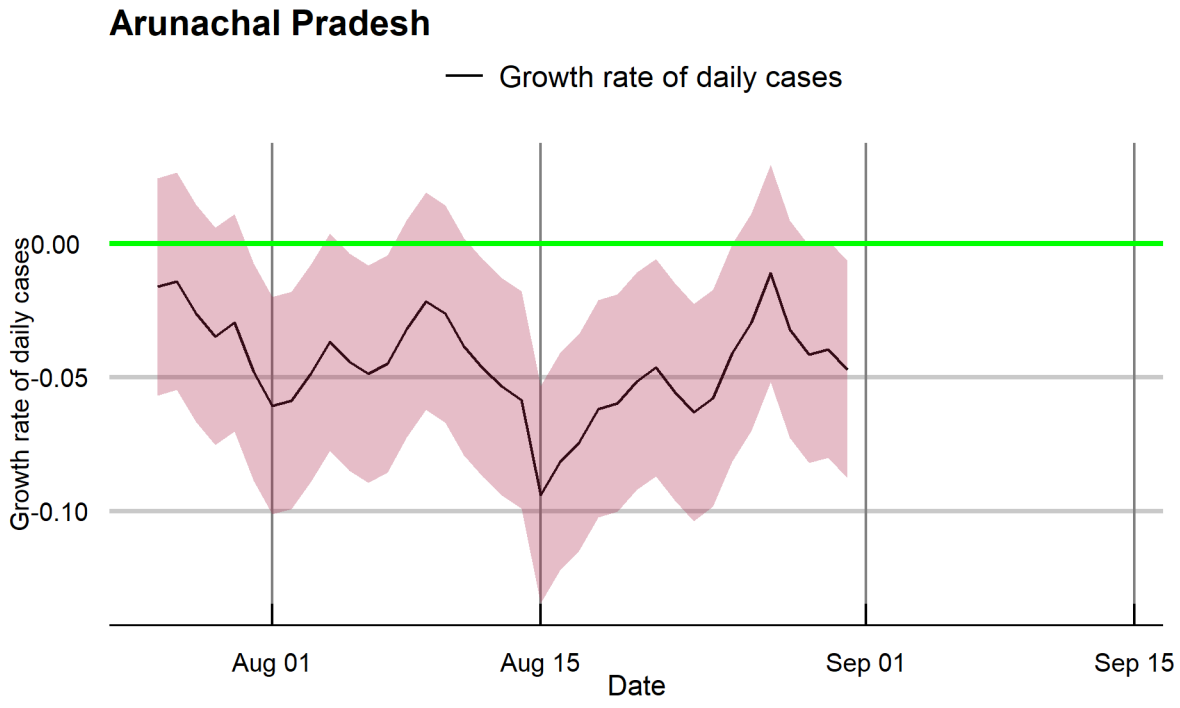

Daily growth rates of cases (%)
Trend values as on 22 August 2021
Latitude
30
20
10
70
80
90
Longitude
gr
0
-4
-8

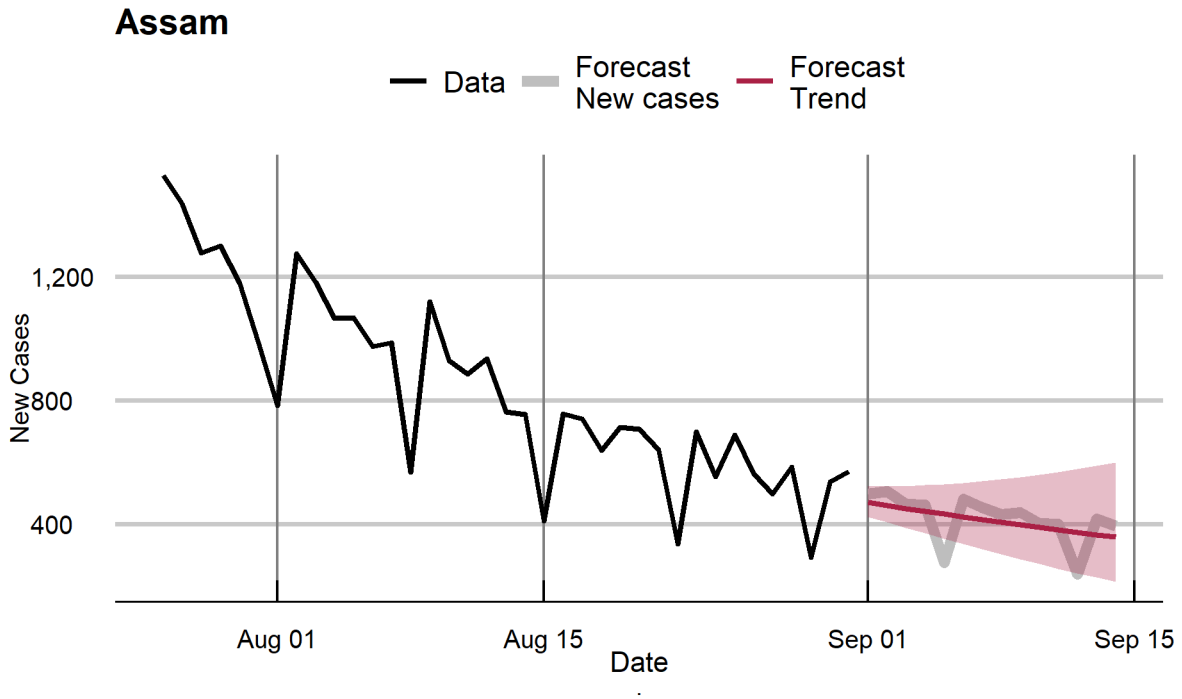
Case forecasts and growth rates: States and Union territories

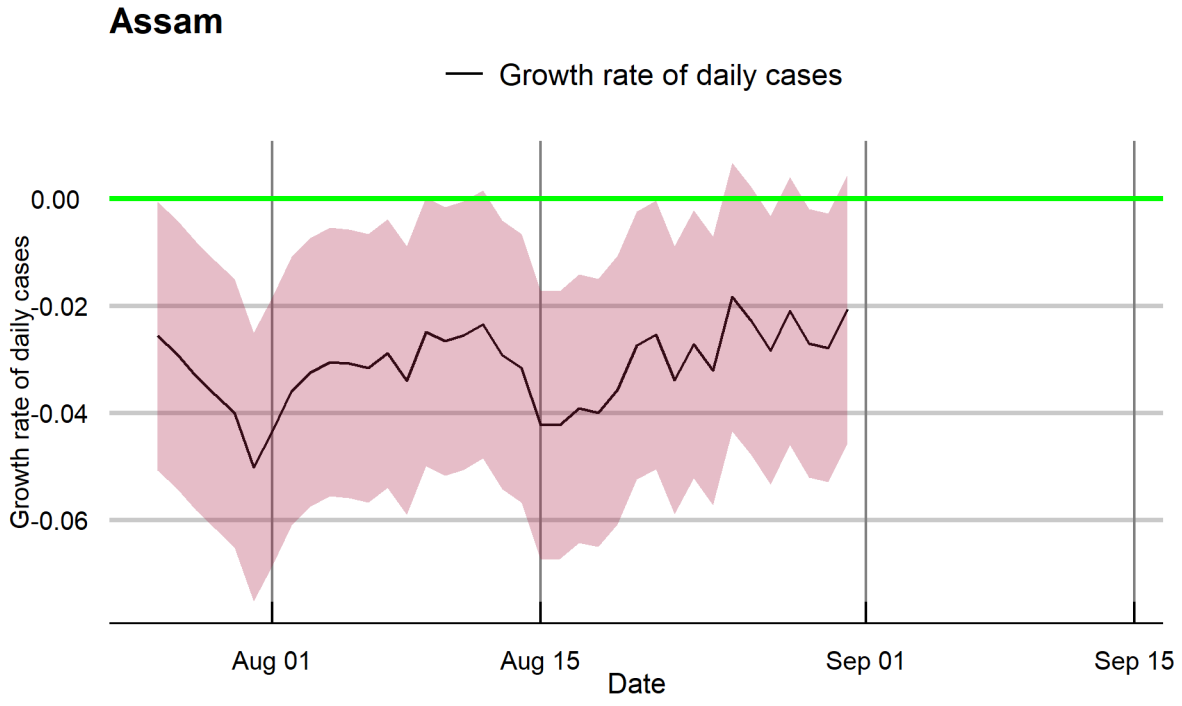


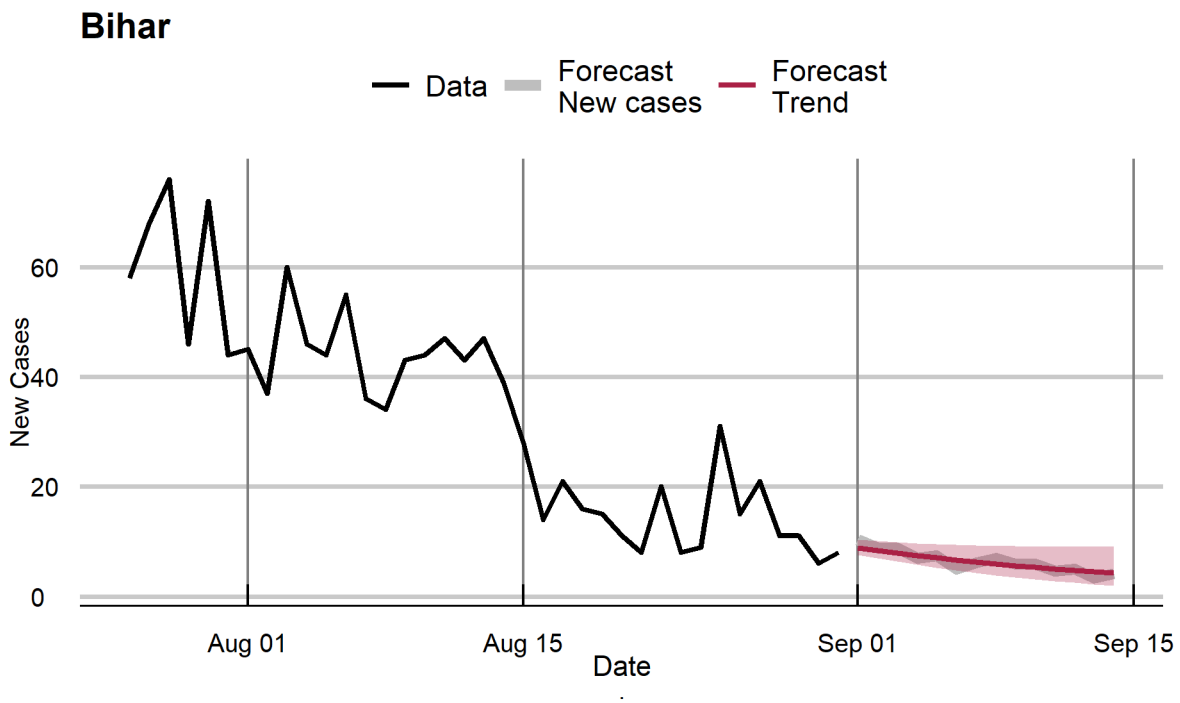


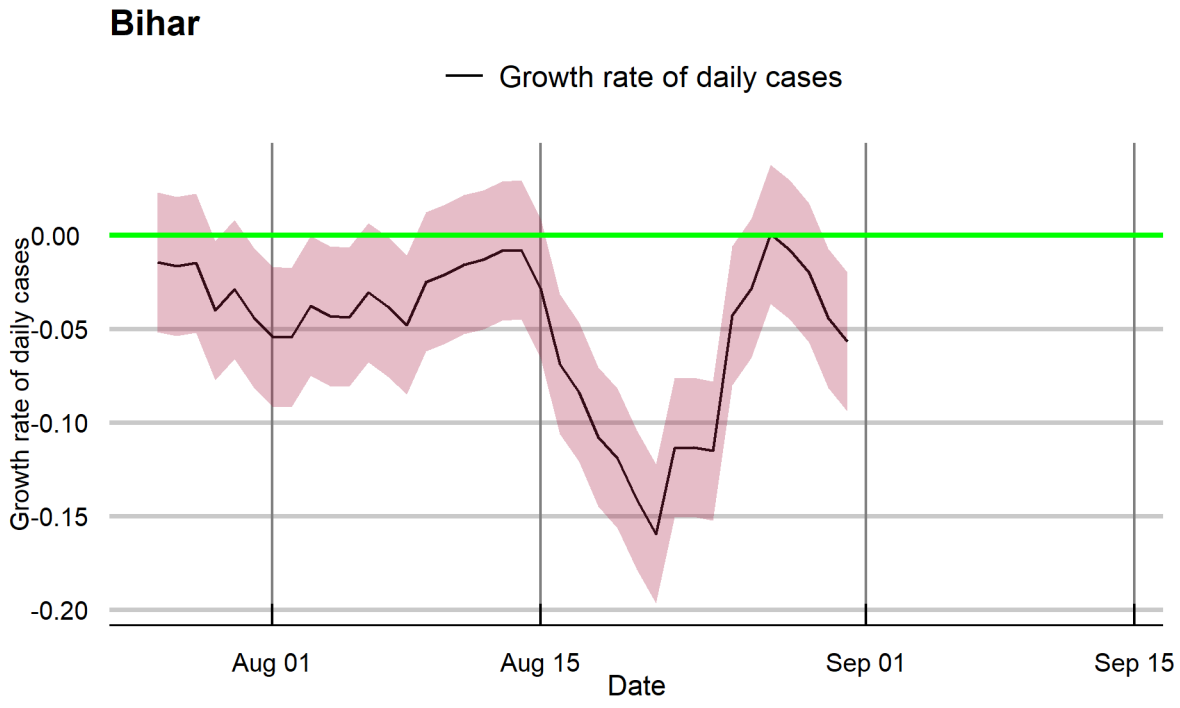

Arunachal Pradesh
Data
Forecast
New cases
Forecast
Trend
500
400
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

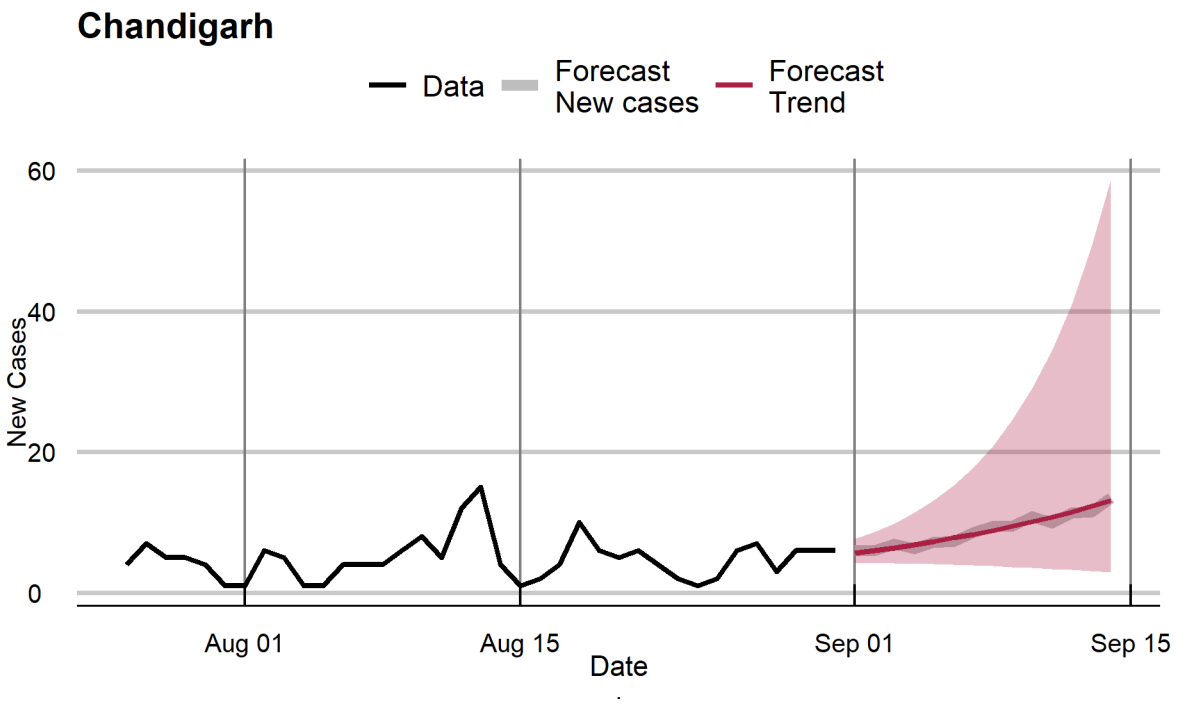

Arunachal Pradesh
Growth rate of daily cases
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

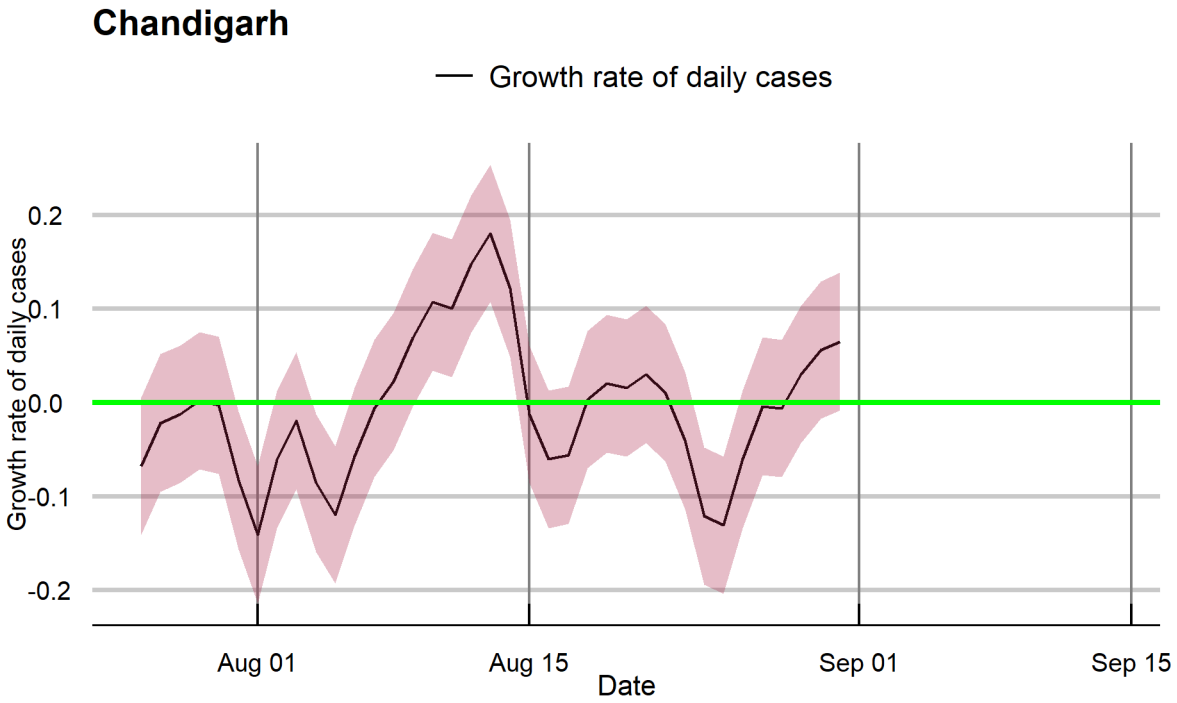

Assam
Data
Forecast
New cases
Forecast
Trend
1,200
800
400
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

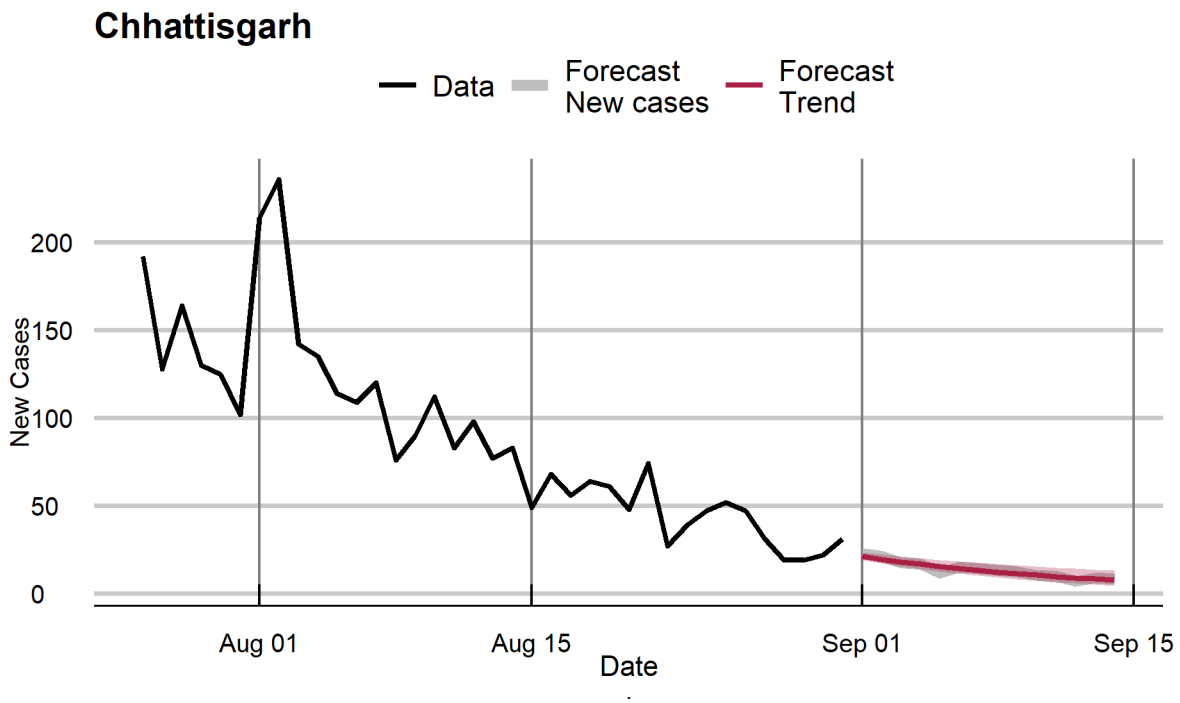

Assam
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

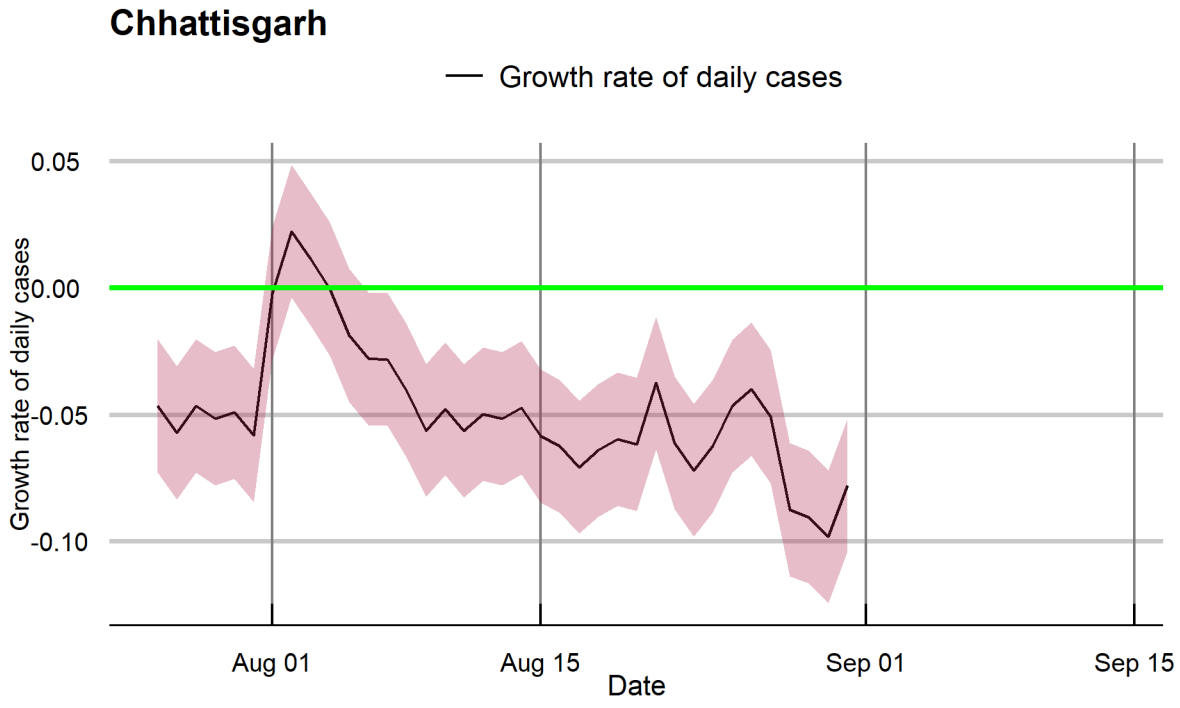

Bihar
Data
Forecast
New cases
Forecast
Trend
New Cases
60
40
20
0
Aug 01
Aug 15
Sep 01
Sep 15
Date

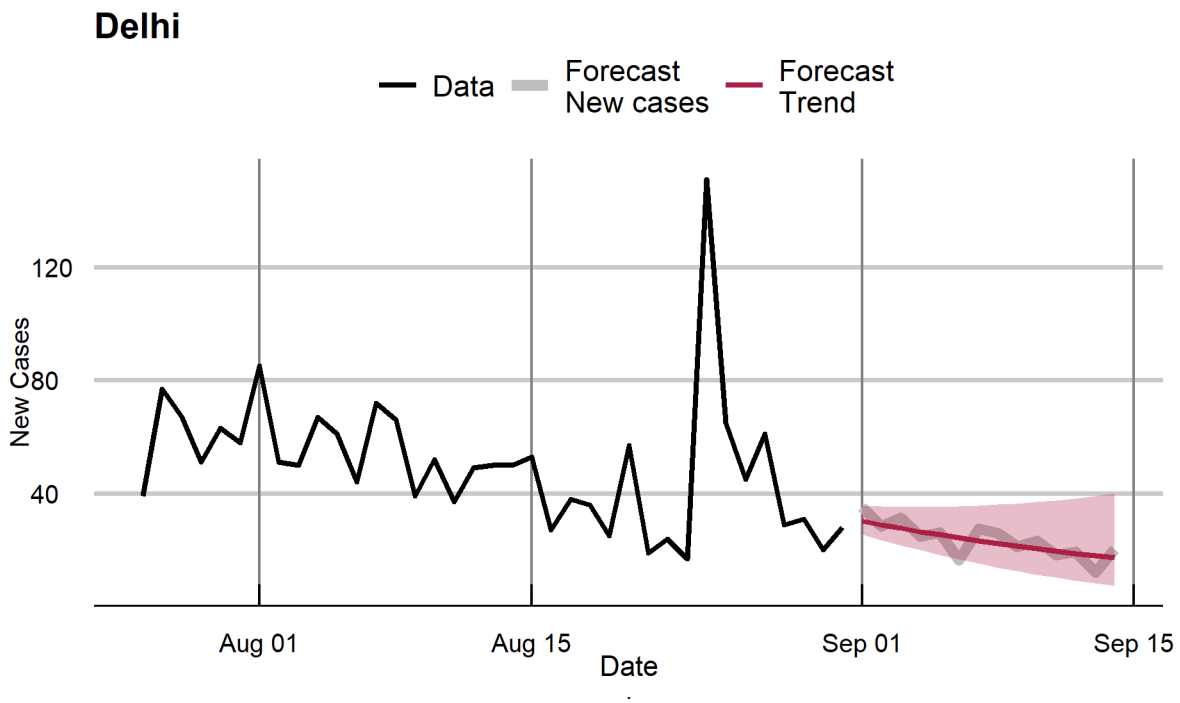

Bihar
Growth rate of daily cases
Growth rate of daily cases
0.00
-0.05
-0.10
-0.15
-0.20
Aug 01
Aug 15
Sep 01
Sep 15
Date

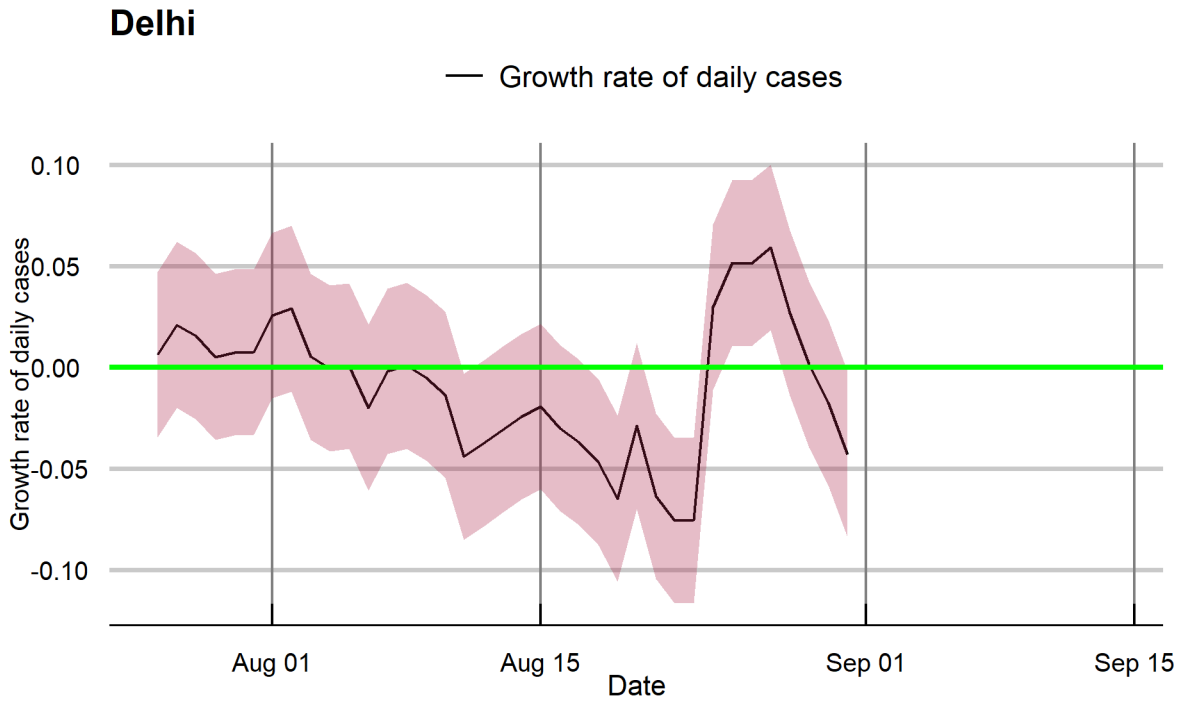

Chandigarh
Data
Forecast
New cases
Forecast
Trend
60
40
20
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

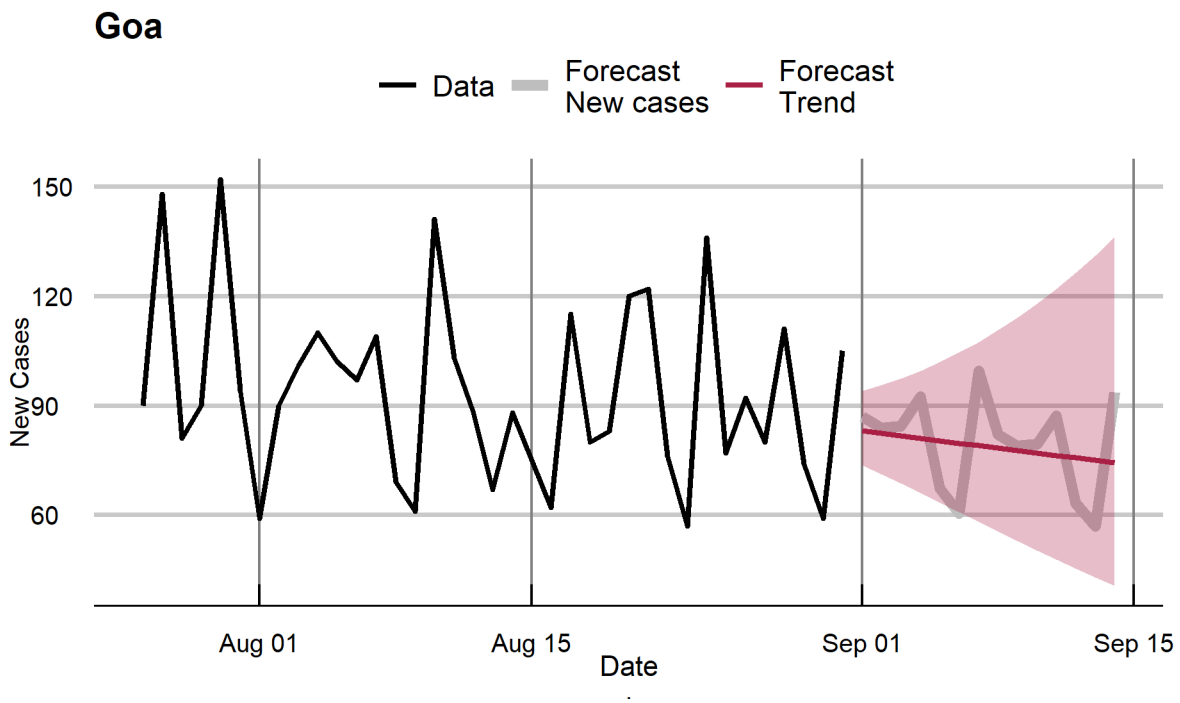

Chandigarh
Growth rate of daily cases
0.2
0.1
0.0
-0.1
-0.2
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

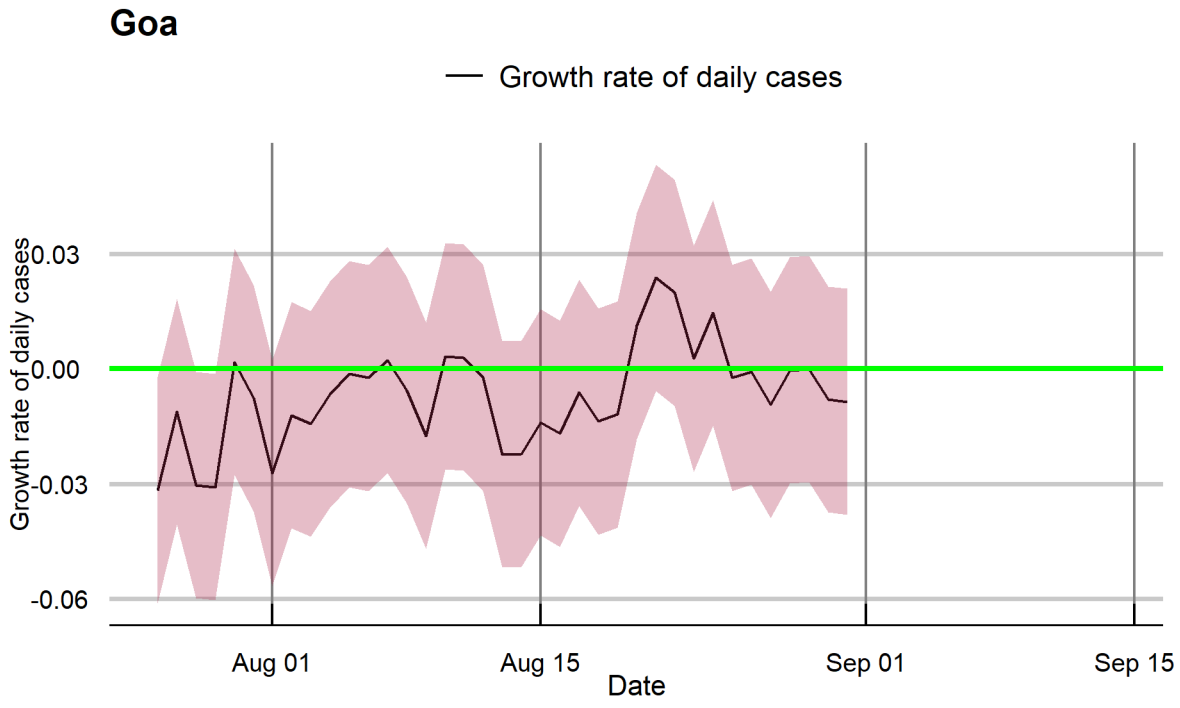

Chhattisgarh
Data
Forecast
New cases
Forecast
Trend
200
150
100
50
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

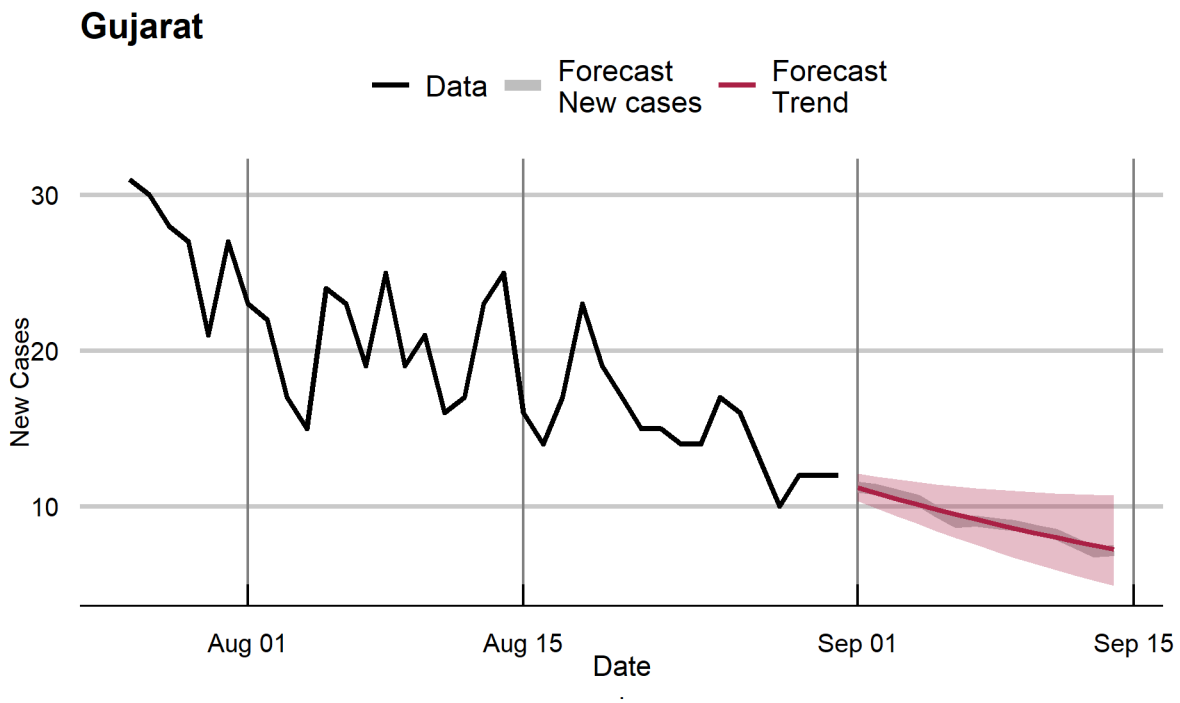

Chhattisgarh
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

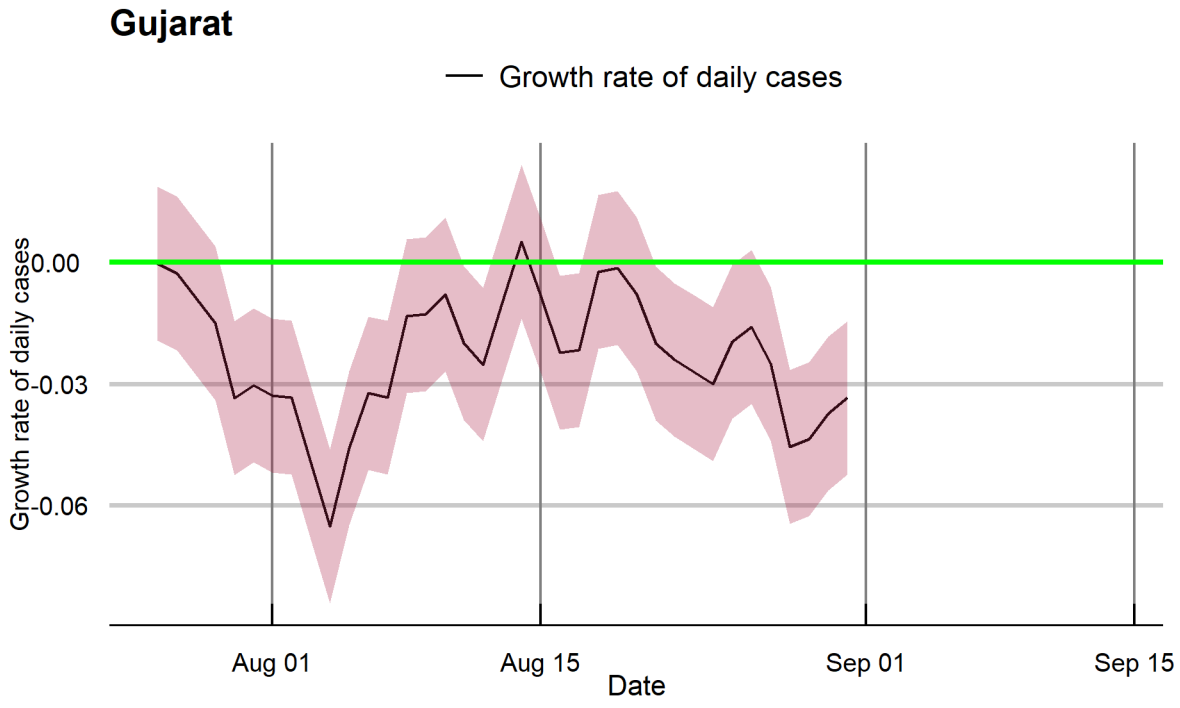

Delhi
Data
Forecast
New cases
Forecast
Trend
120
80
40
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

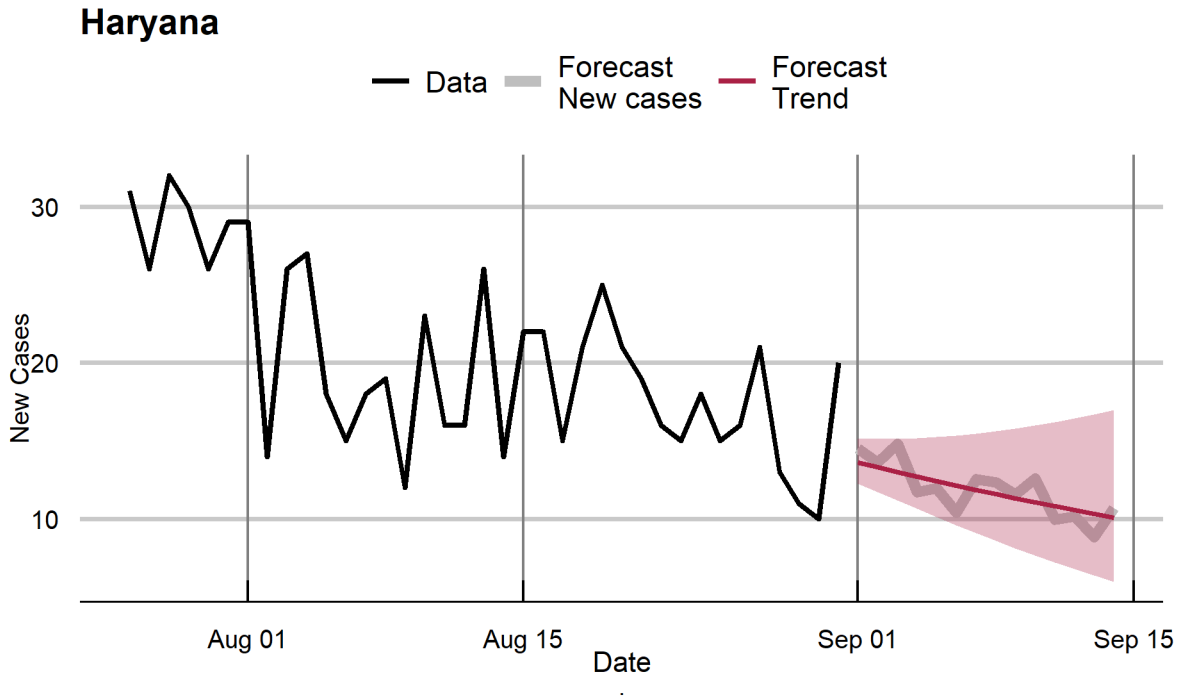

Delhi
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

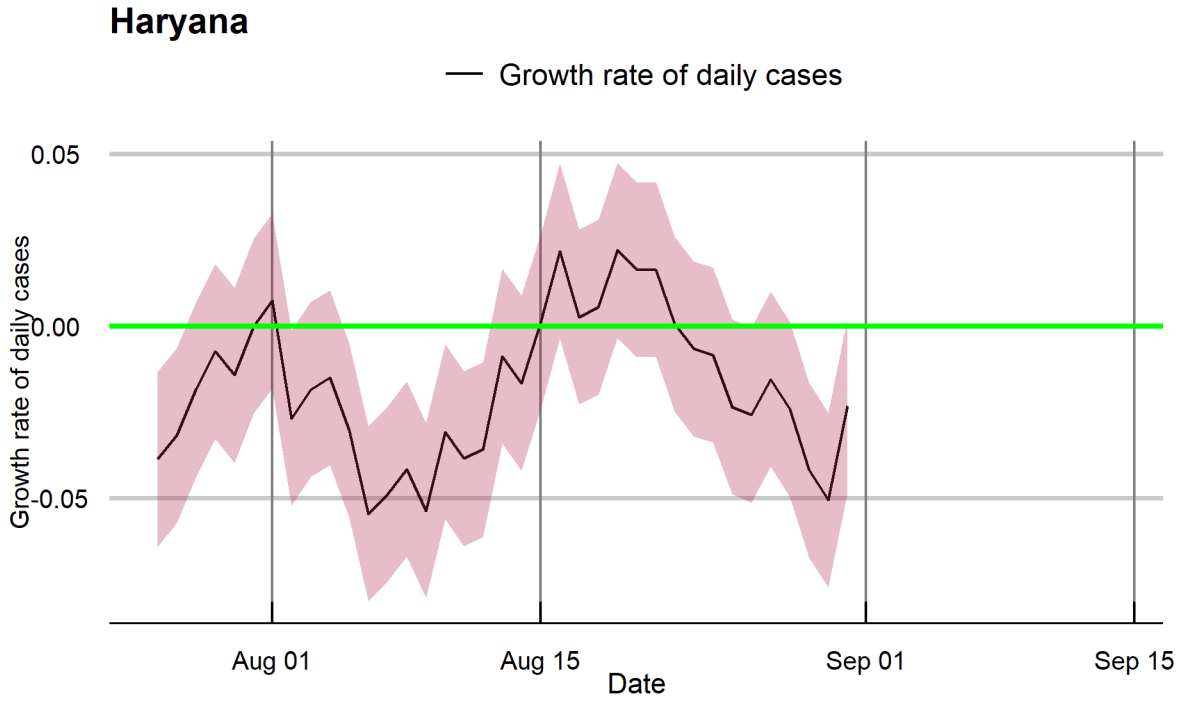

Goa
Data
Forecast
New cases
Forecast
Trend
150
120
90
60
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

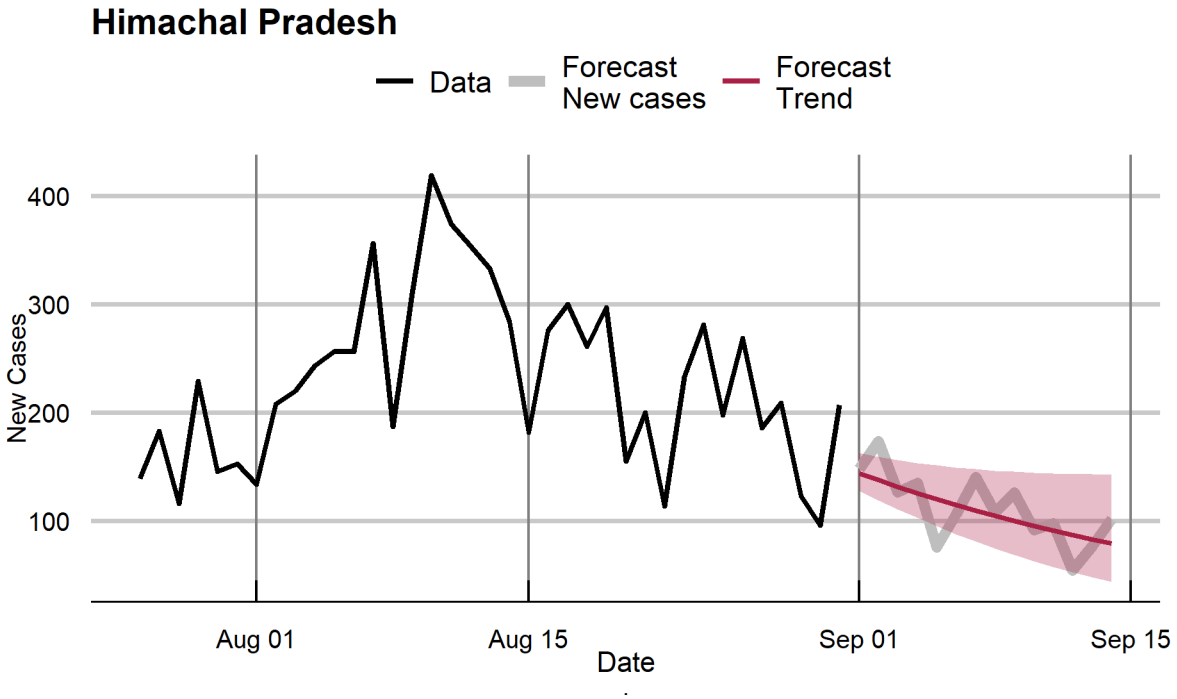

Goa
Growth rate of daily cases
0.03
0.00
-0.03
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

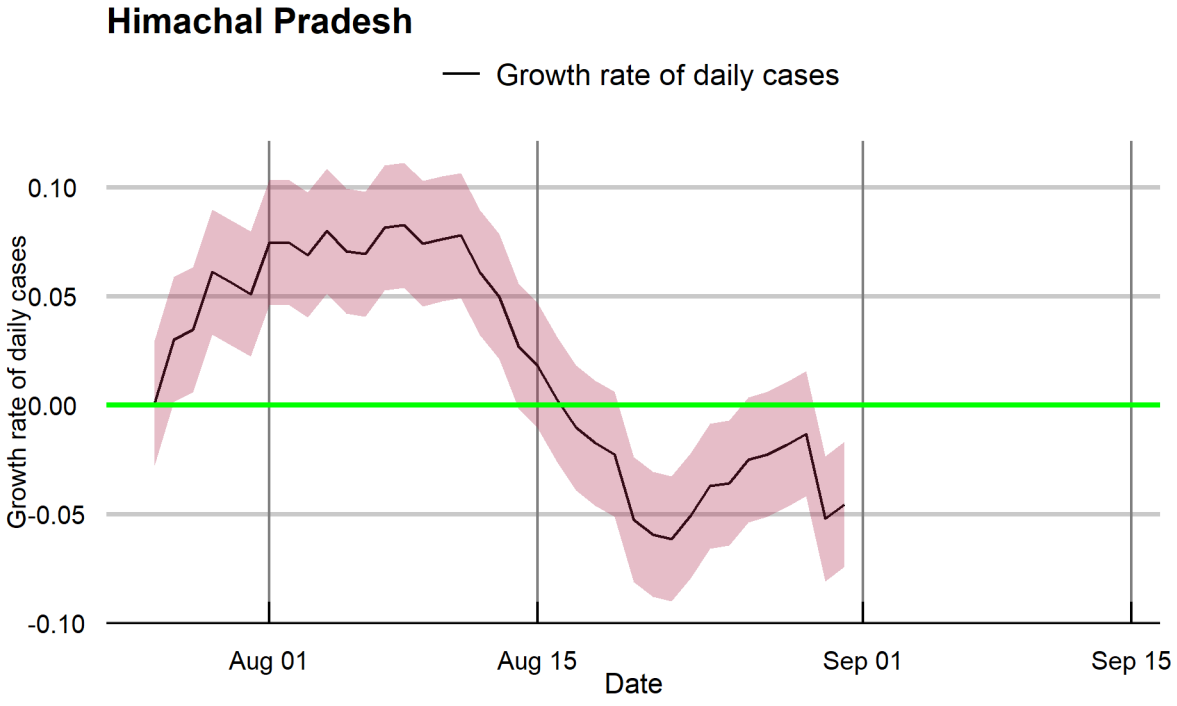

Gujarat
Data
Forecast
New cases
Forecast
Trend
30
20
10
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

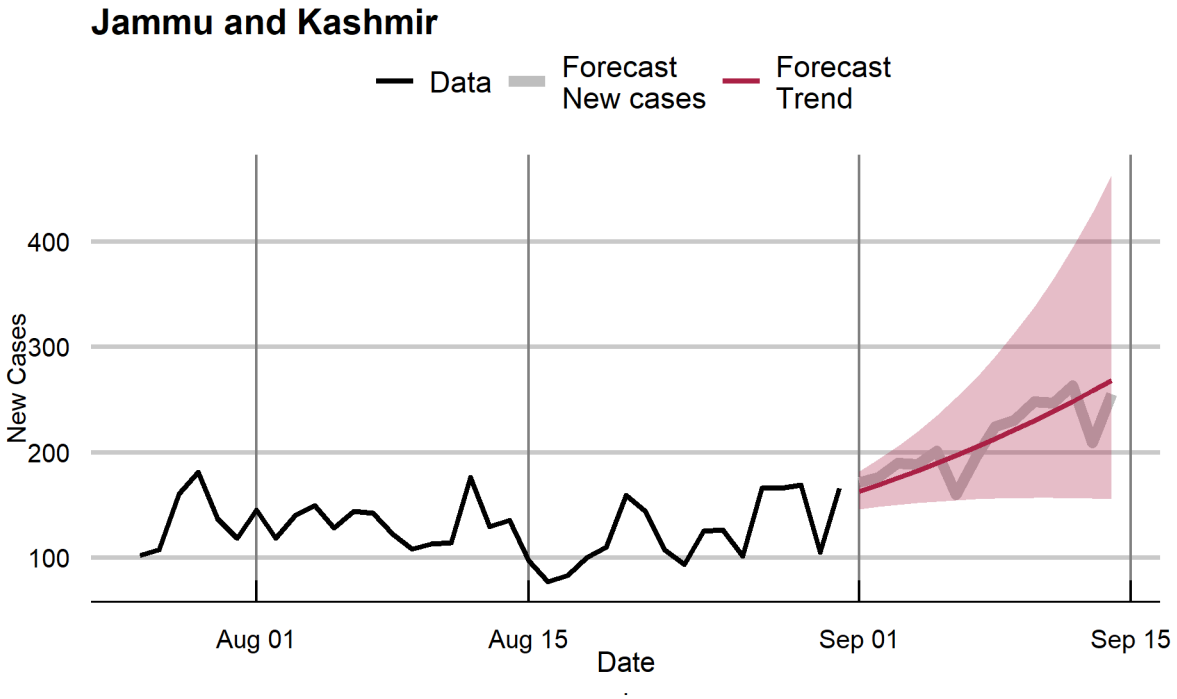

Gujarat
Growth rate of daily cases
0.00
-0.03
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

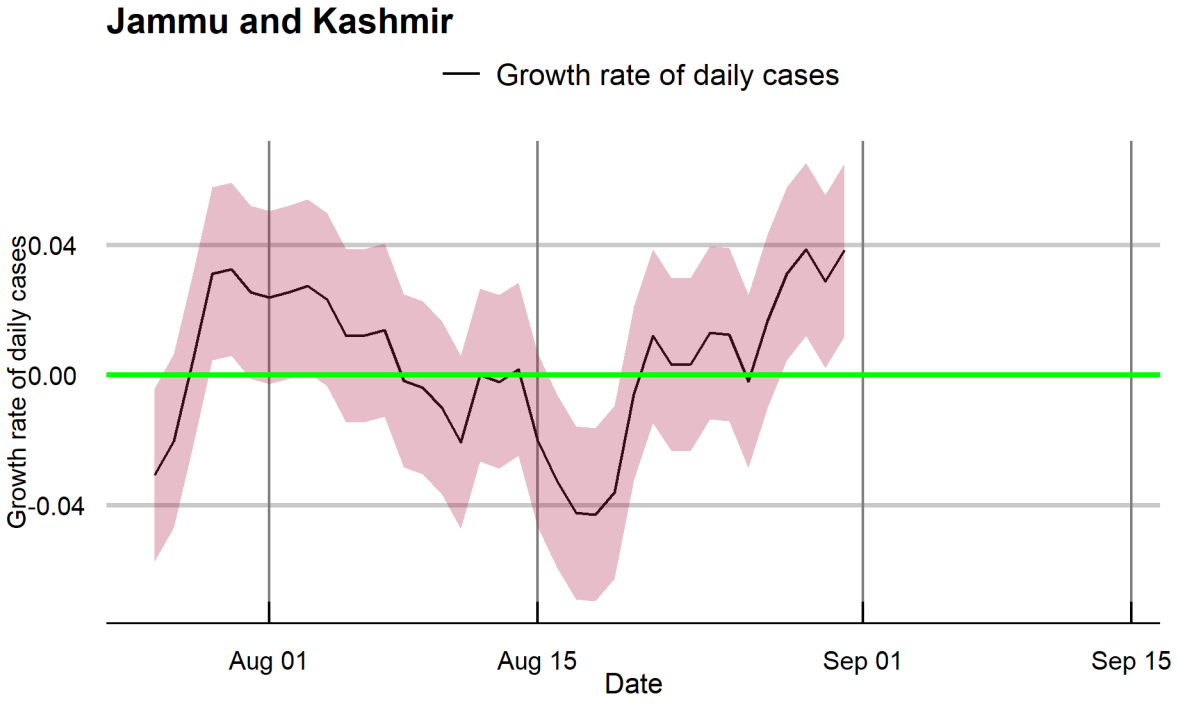

Haryana
Data
Forecast
New cases
Forecast
Trend
30
20
10
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

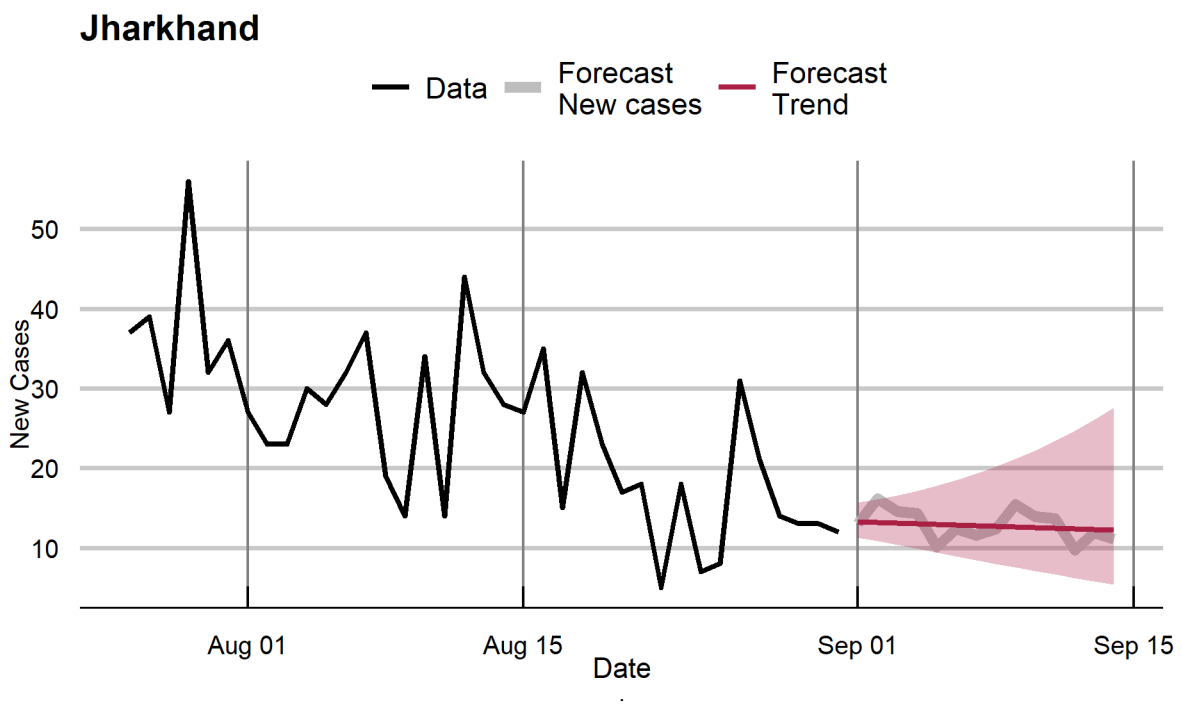

Haryana
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

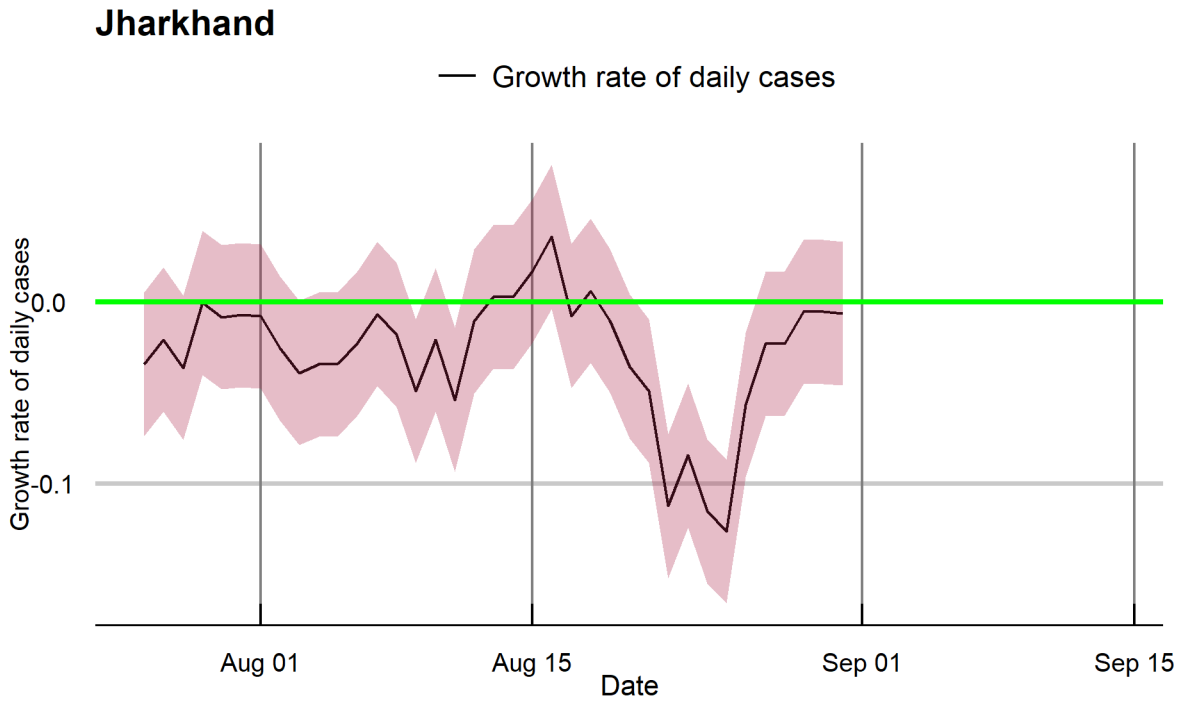

Himachal Pradesh
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

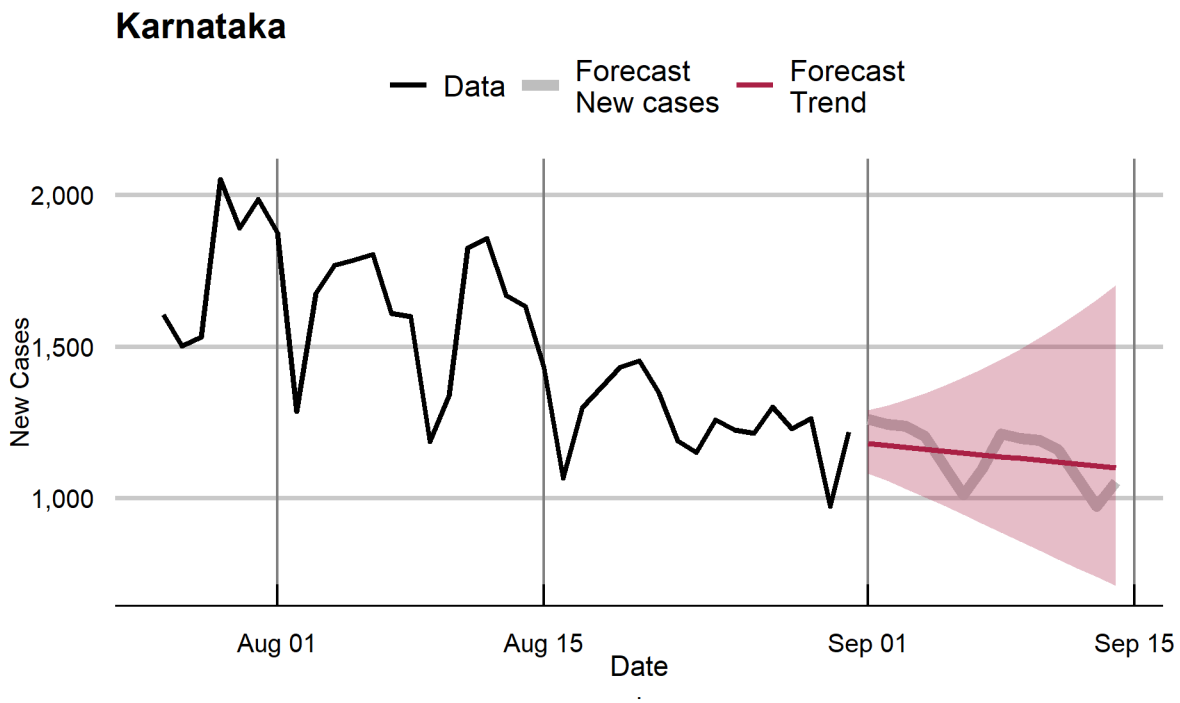

Himachal Pradesh
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

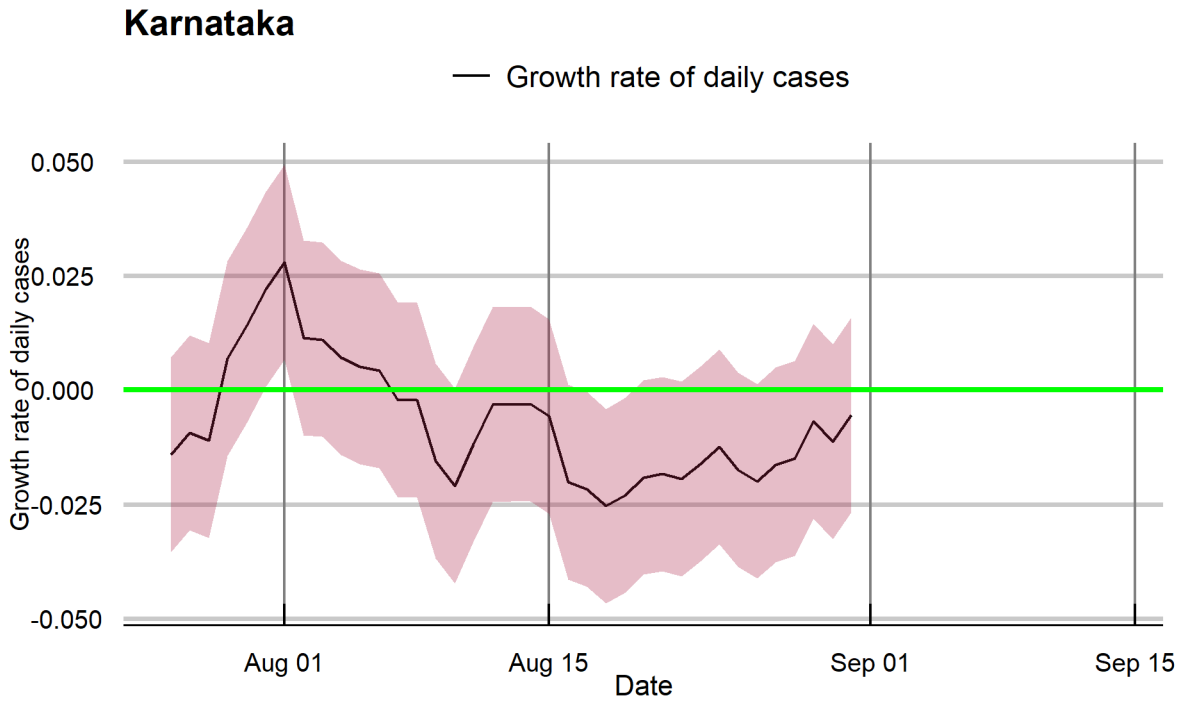

Jammu and Kashmir
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

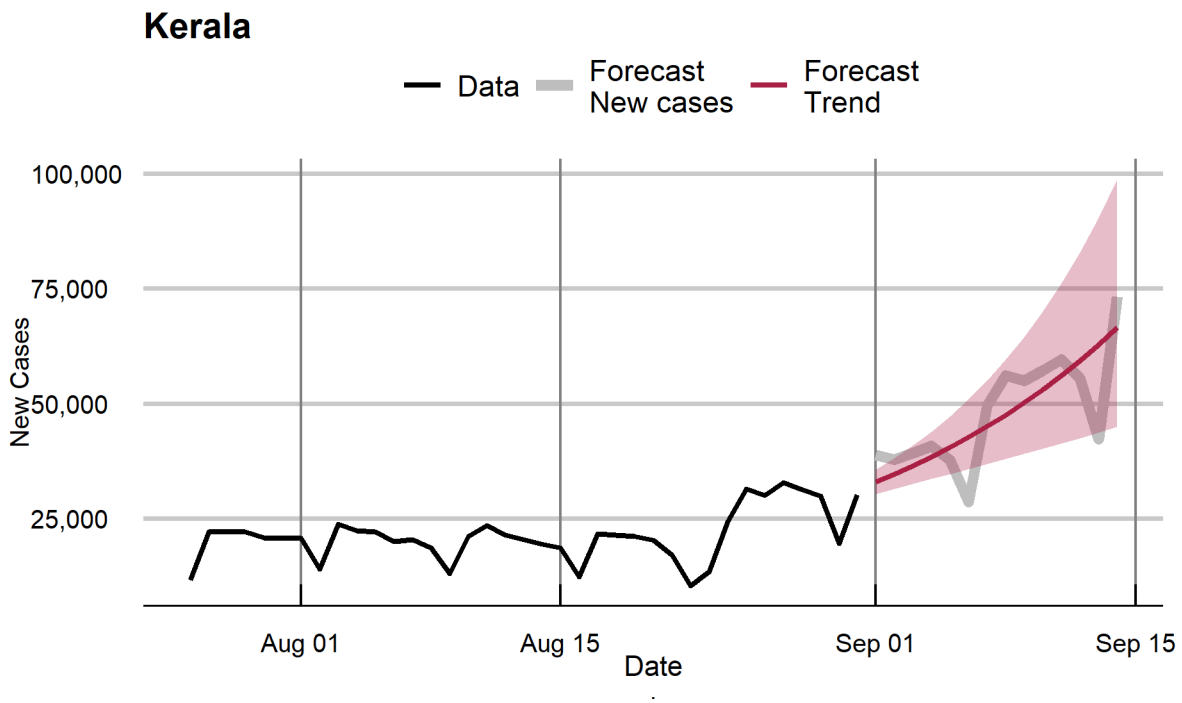

Jammu and Kashmir
Growth rate of daily cases
0.04
0.00
-0.04
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

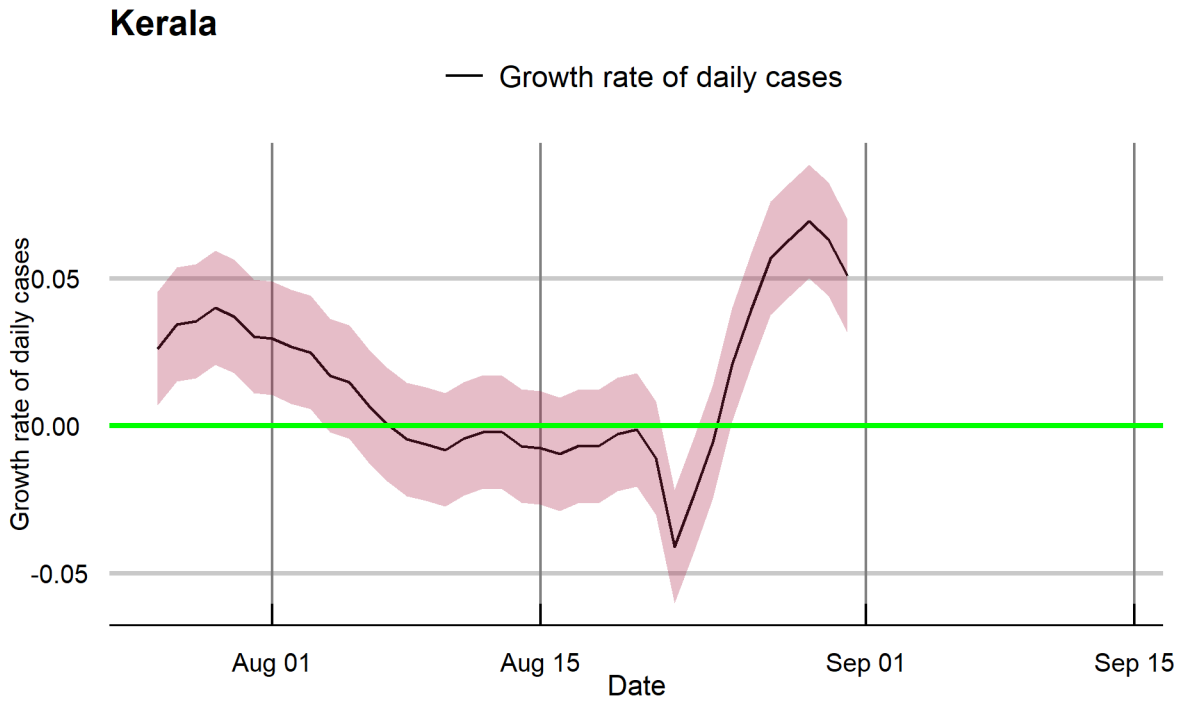

Jharkhand
Data
Forecast
New cases
Forecast
Trend
New Cases
50
40
30
20
10
Aug 01
Aug 15
Sep 01
Sep 15
Date

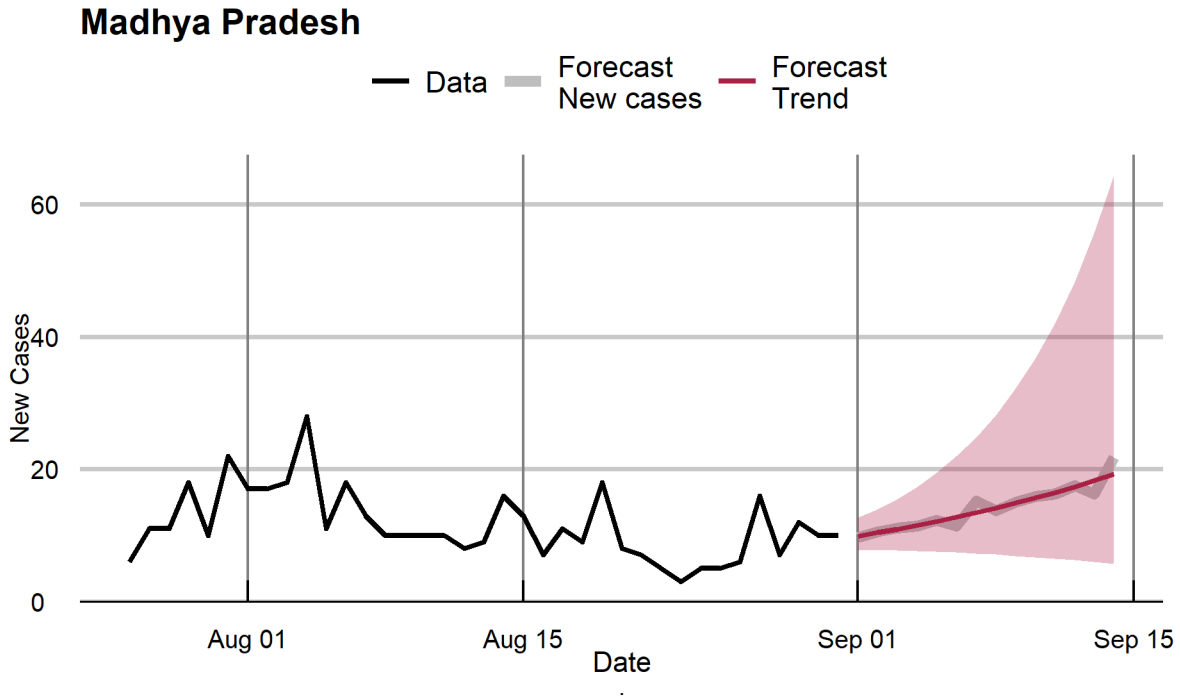

Jharkhand
Growth rate of daily cases
Growth rate of daily cases
0.0
-0.1
Aug 01
Aug 15
Sep 01
Sep 15
Date

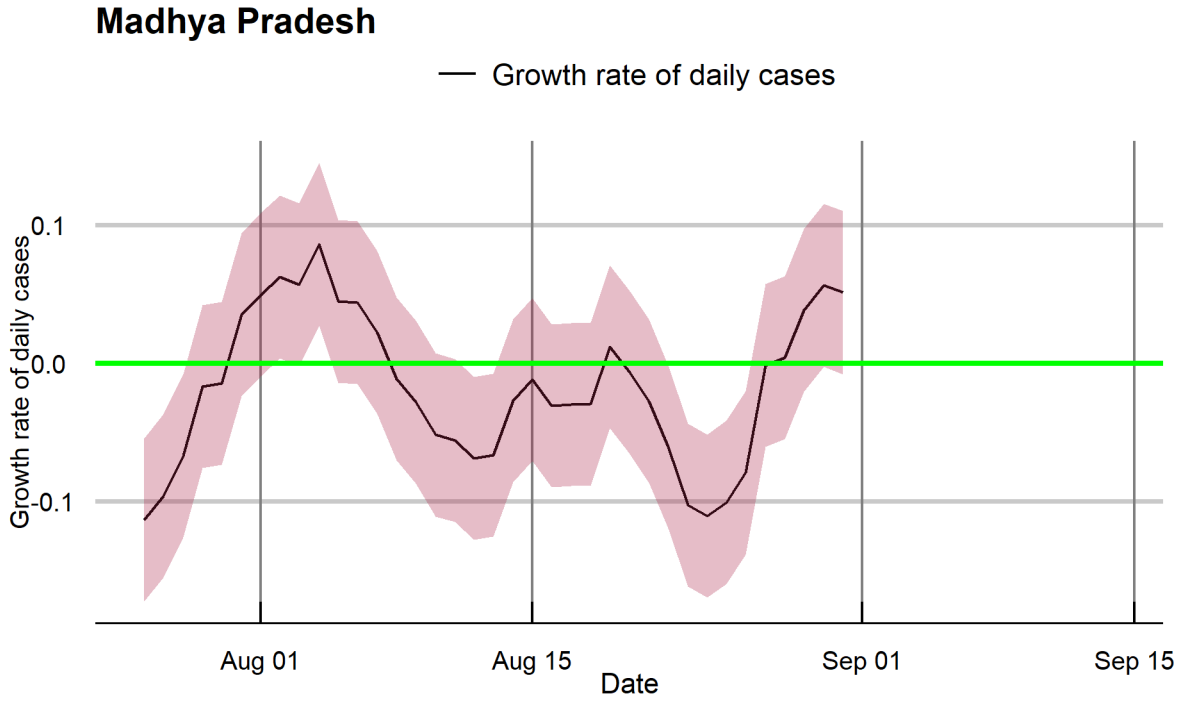

Karnataka
Data
Forecast
New cases
Forecast
Trend
2,000
1,500
1,000
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

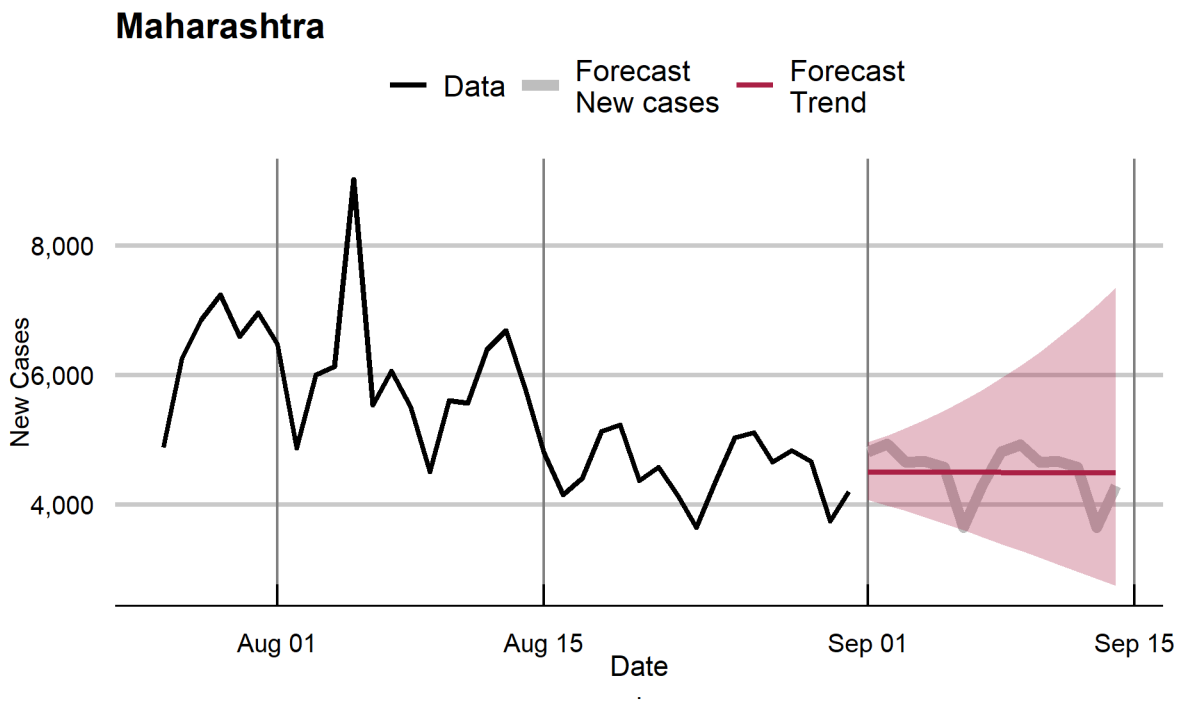

Karnataka
Growth rate of daily cases
0.050
0.025
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

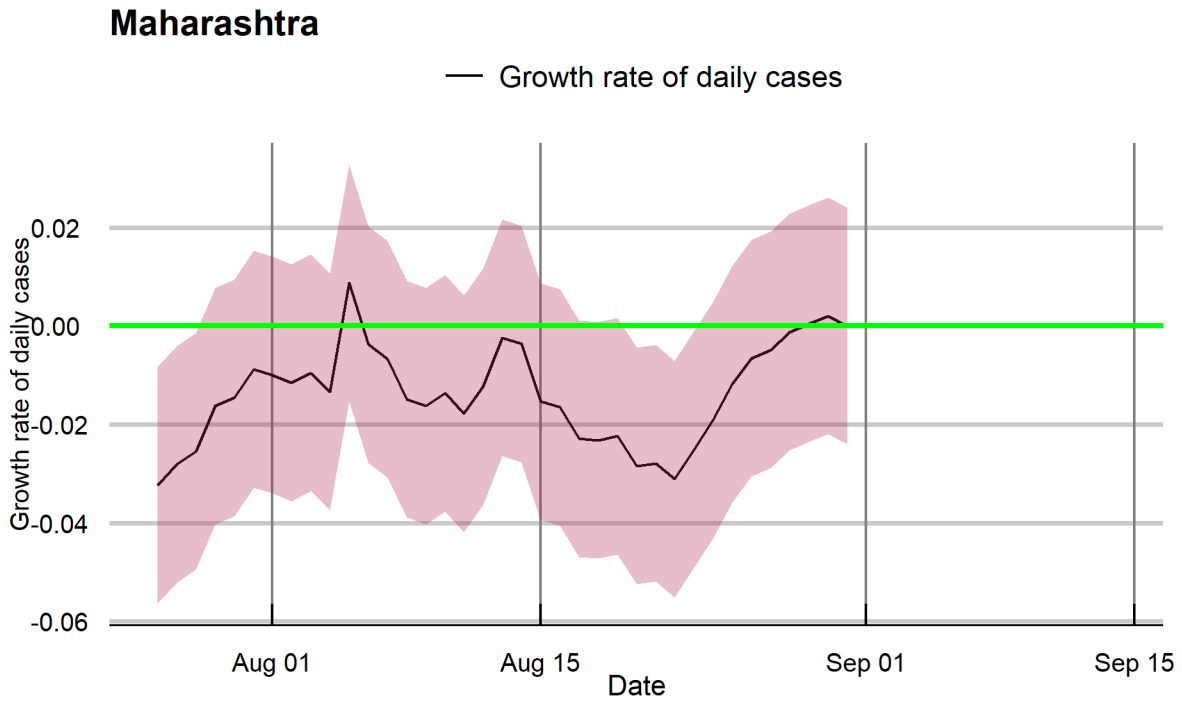

Kerala
Data
Forecast
New cases
Forecast
Trend
100,000
75,000
50,000
25,000
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

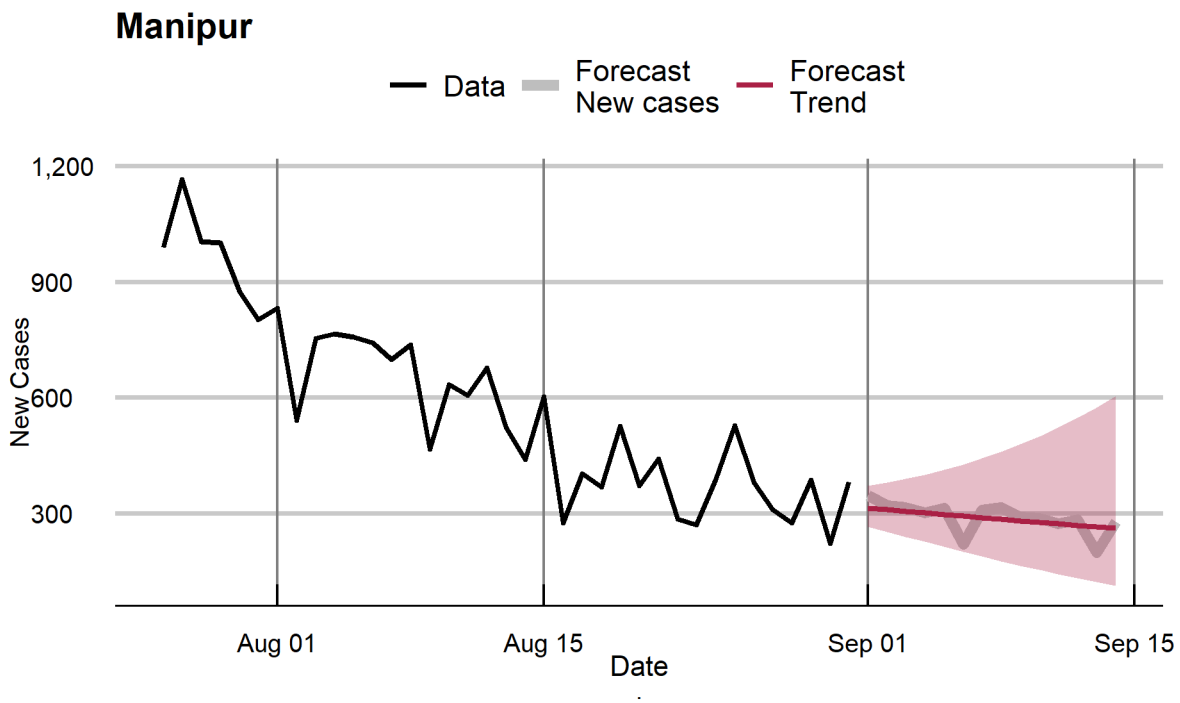

Kerala
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

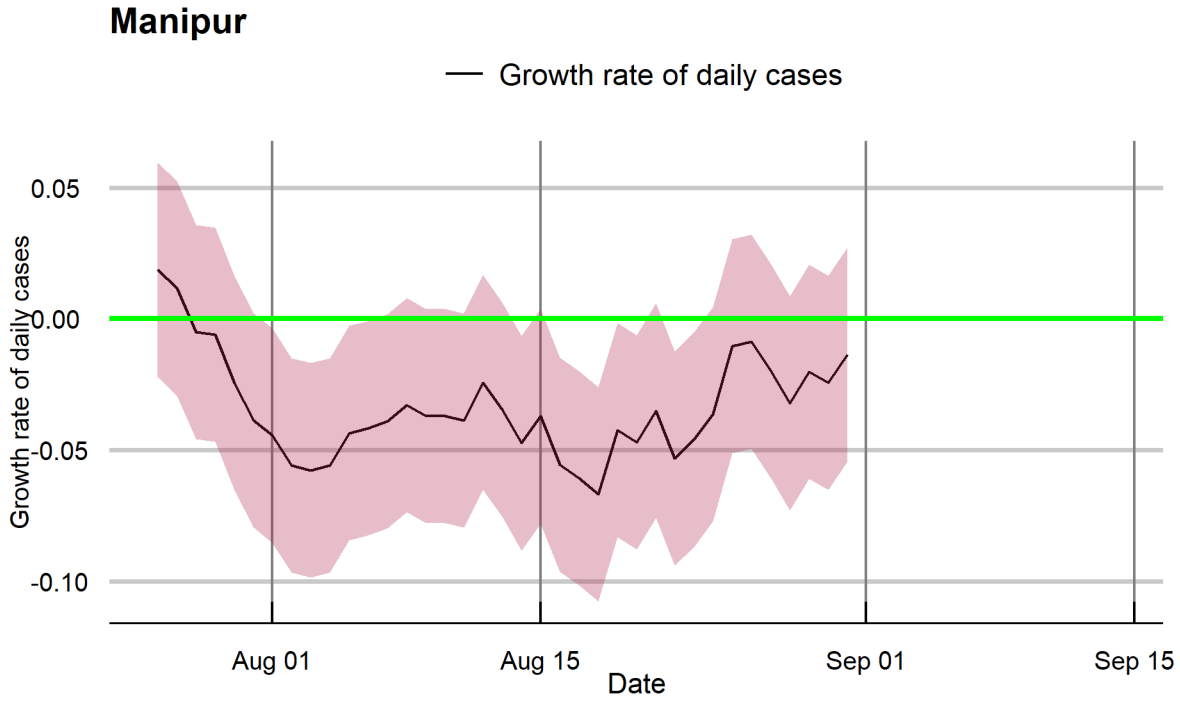

Madhya Pradesh
Data
Forecast
New cases
Forecast
Trend
60
40
20
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

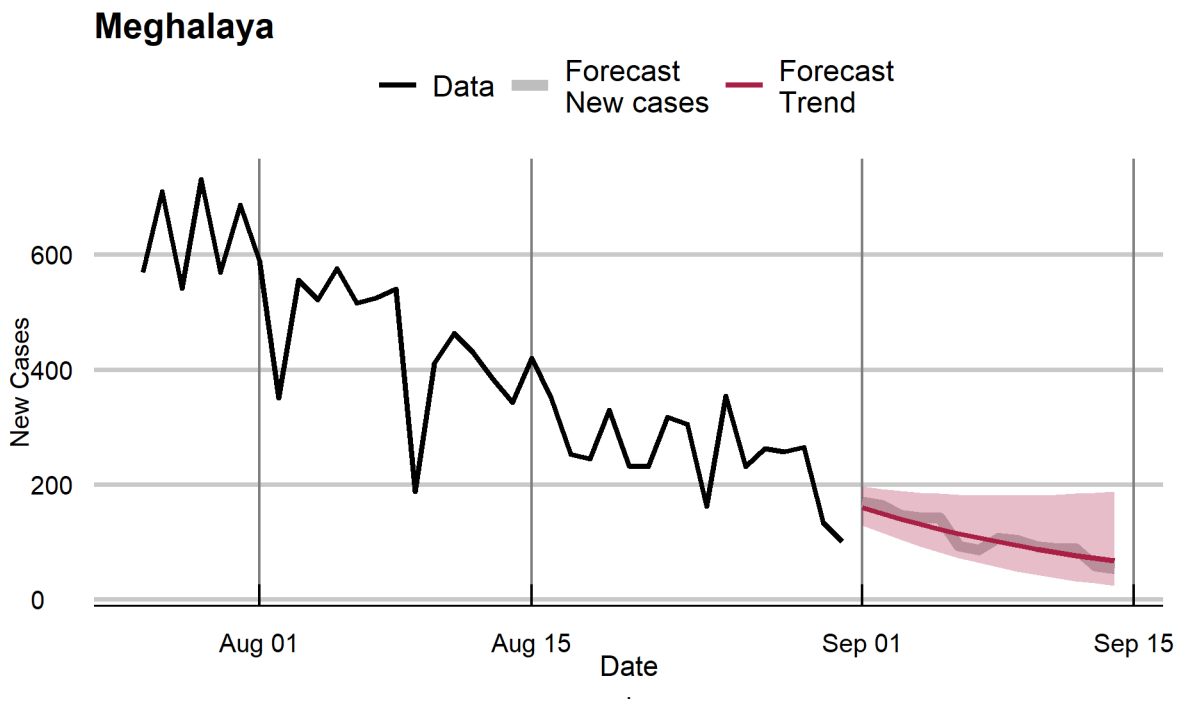

Madhya Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

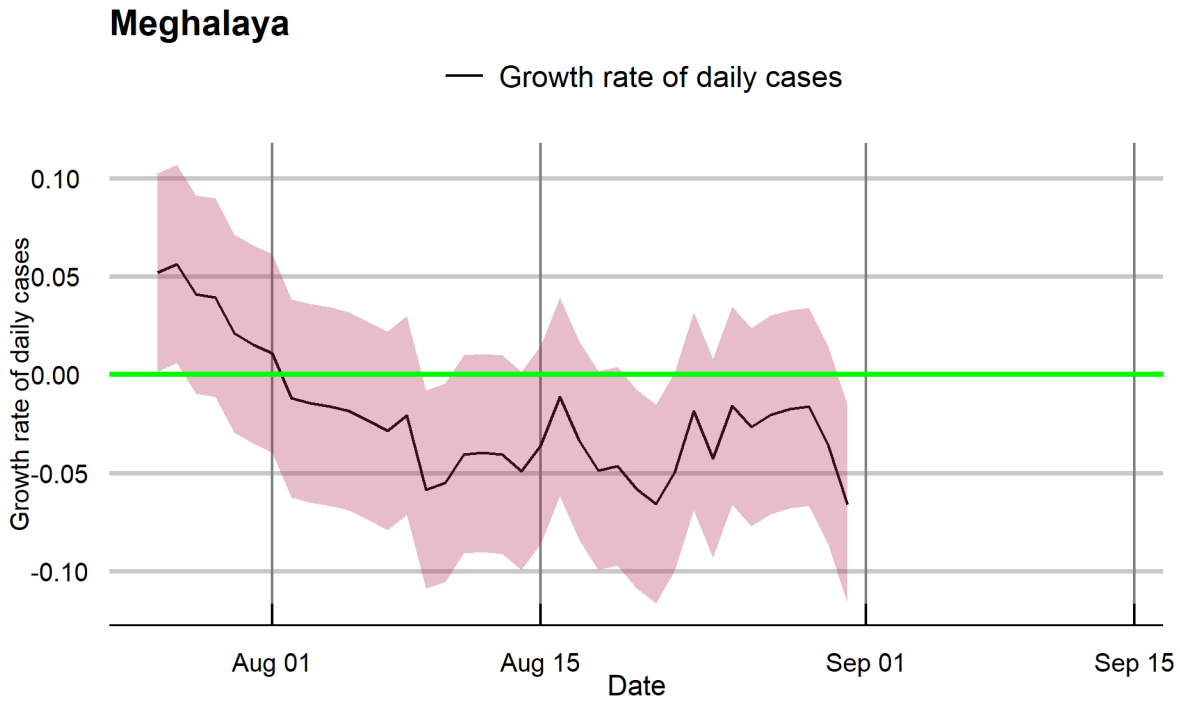

Maharashtra
Data
Forecast
New cases
Forecast
Trend
8,000
6,000
4,000
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

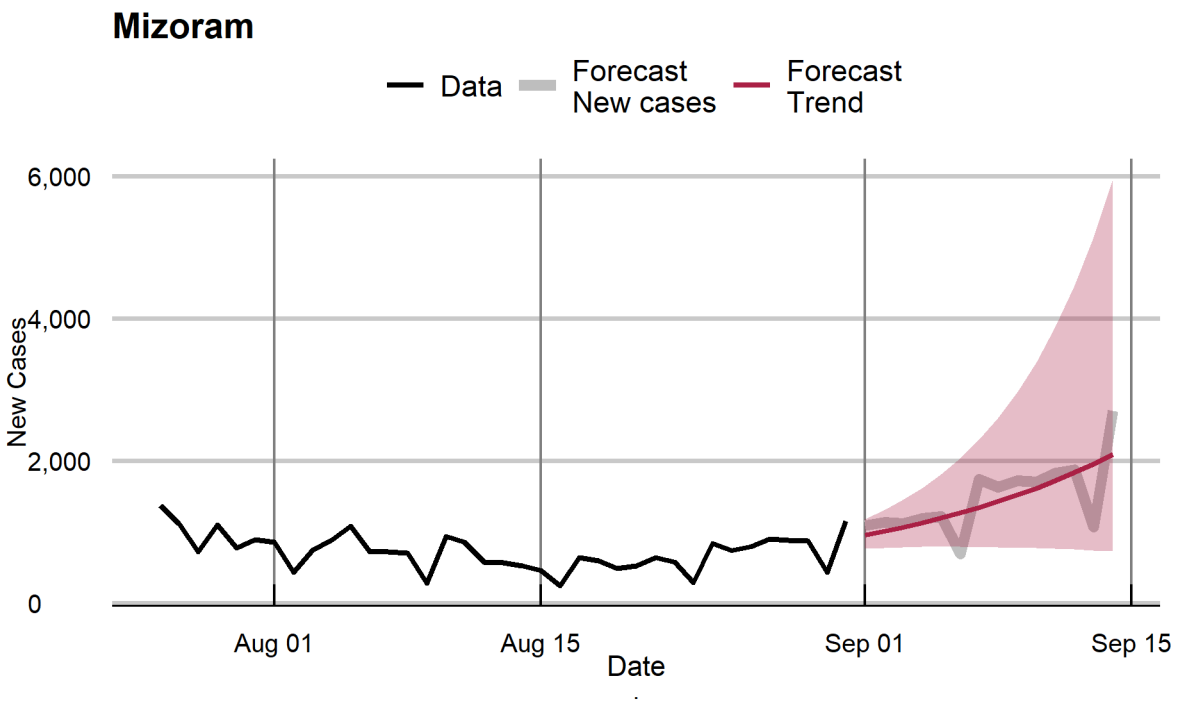

Maharashtra
Growth rate of daily cases
0.02
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

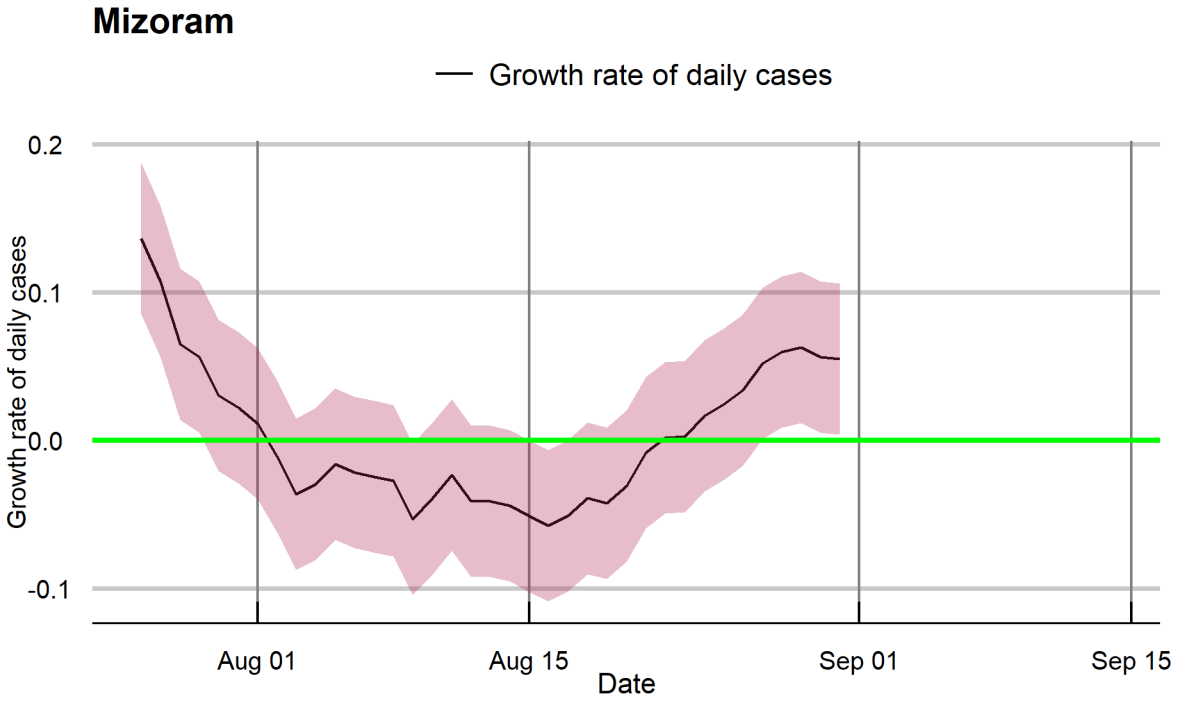

Manipur
Data
Forecast
New cases
Forecast
Trend
1,200
900
600
300
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

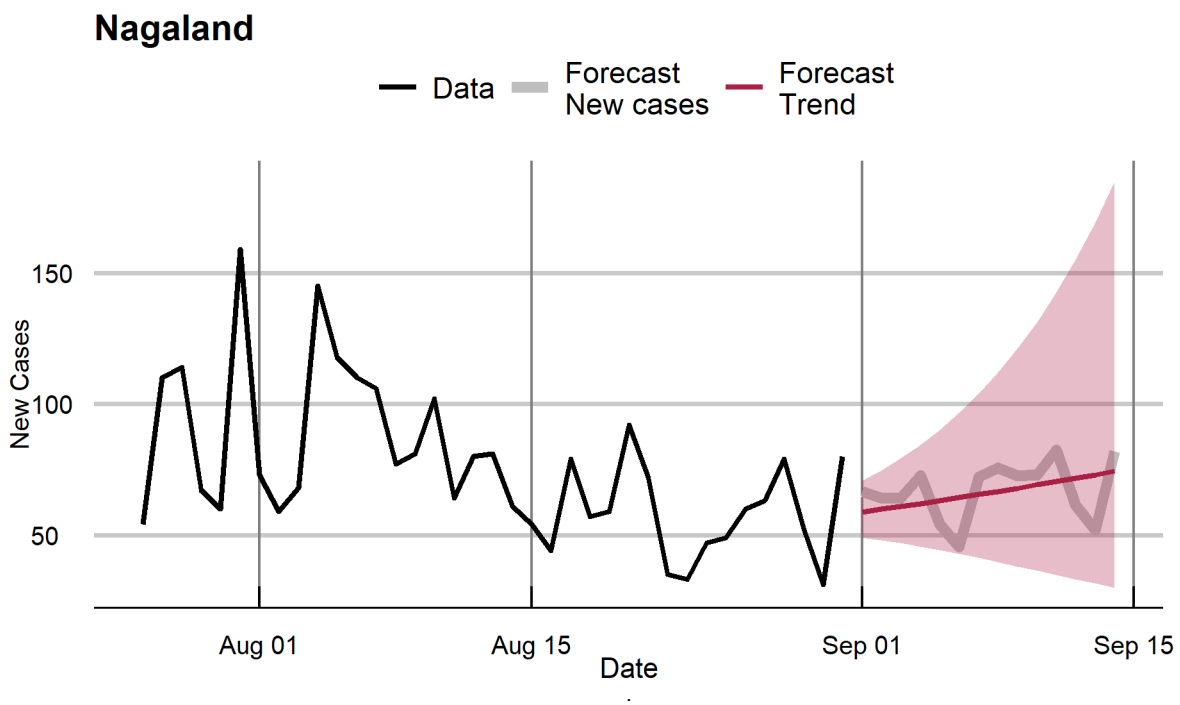

Manipur
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

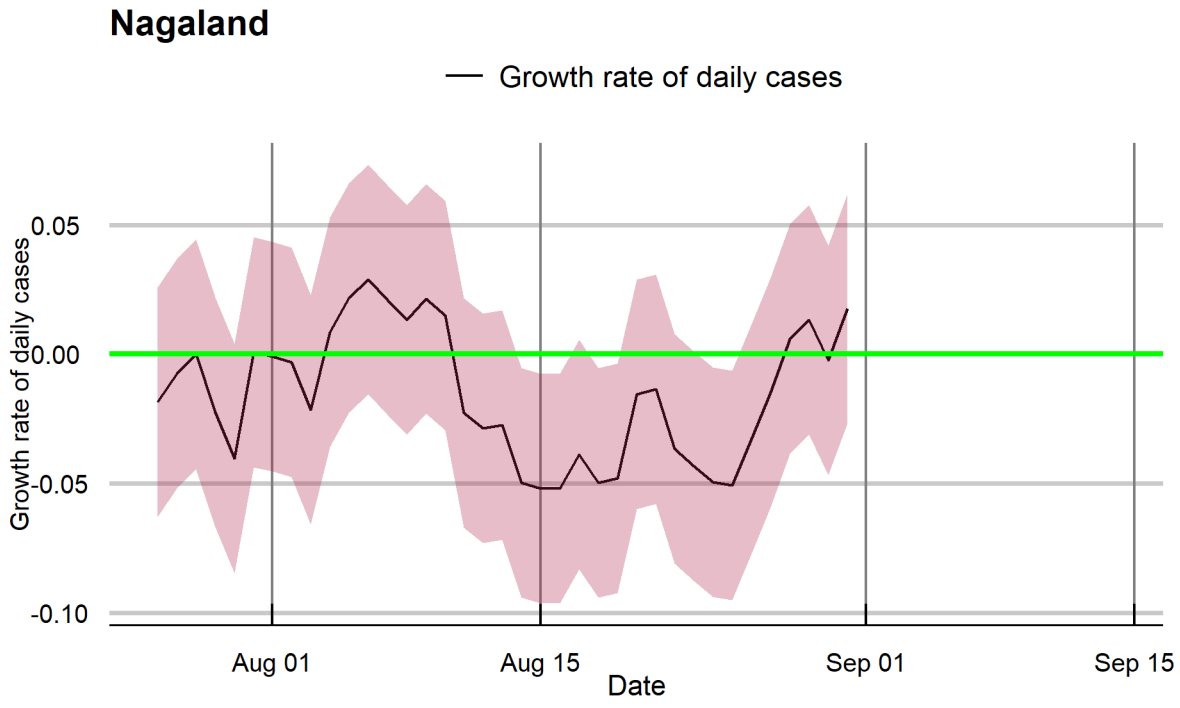

Meghalaya
Data
Forecast
New cases
Forecast
Trend
600
400
200
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

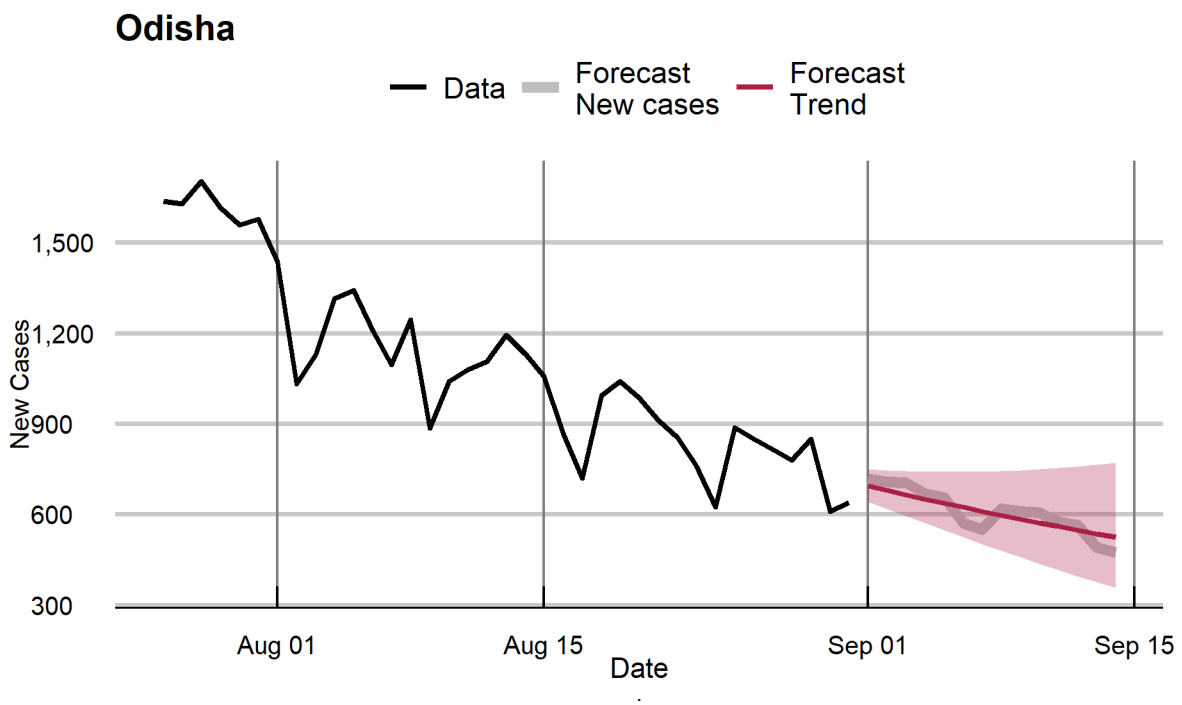

Meghalaya
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

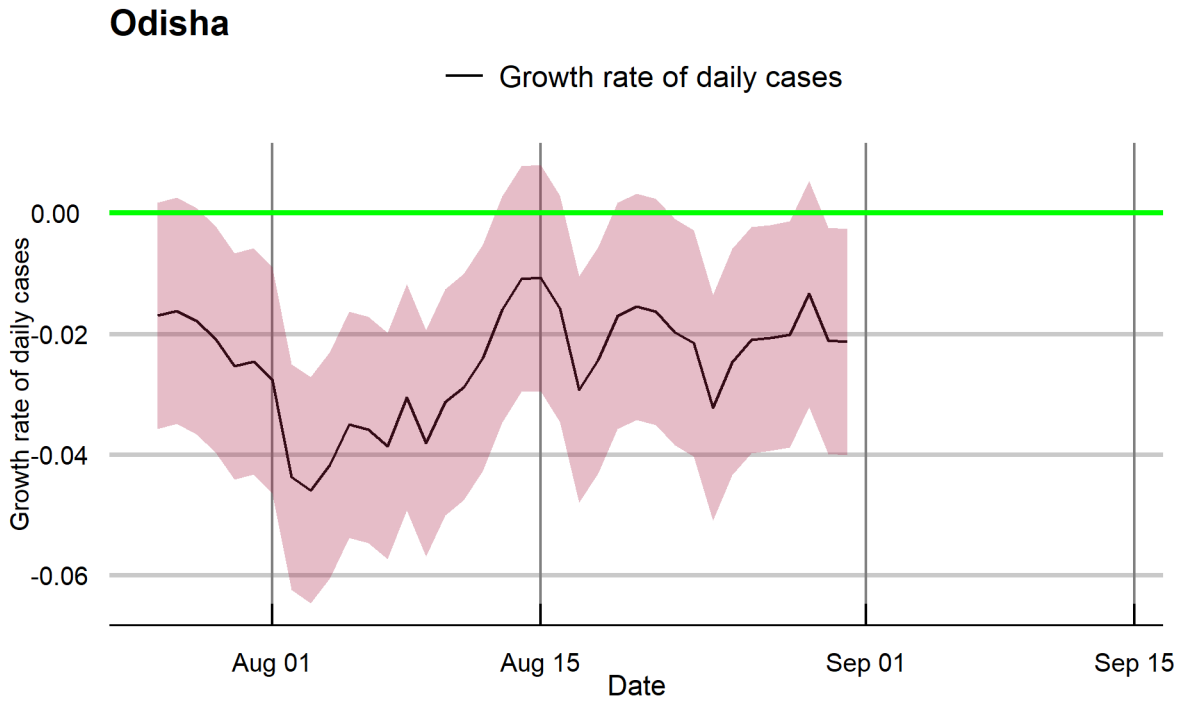

Mizoram
Data
Forecast
New cases
Forecast
Trend
6,000
4,000
2,000
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

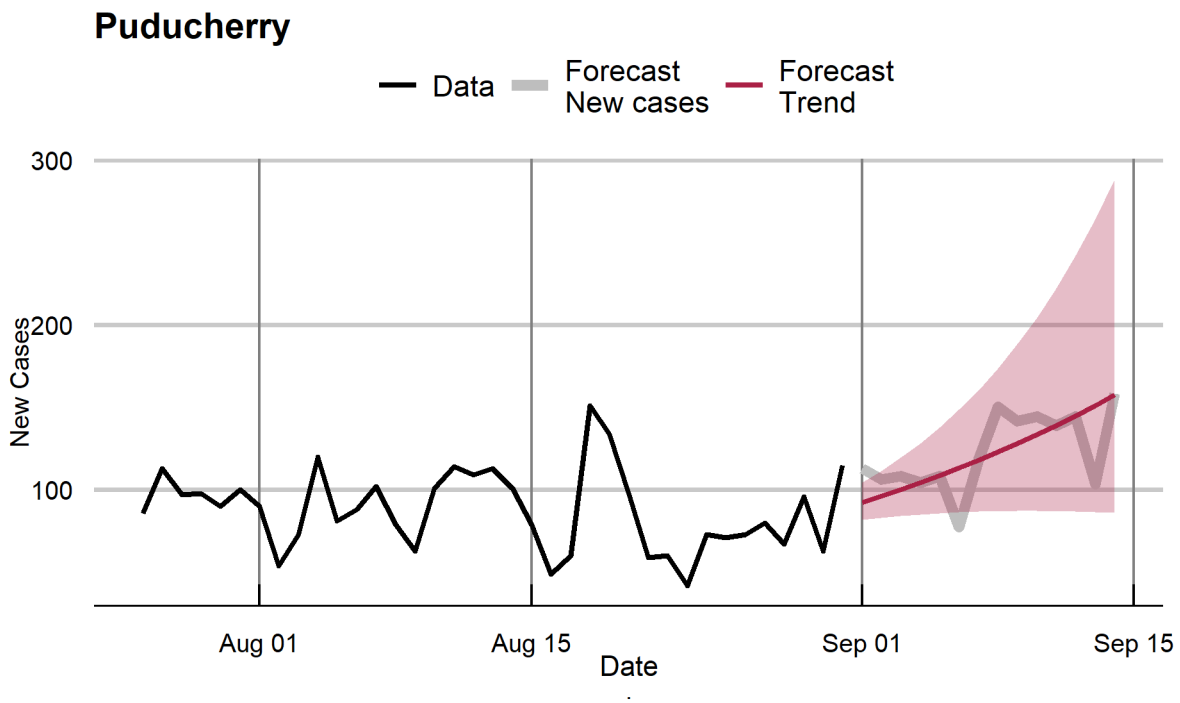

Mizoram
Growth rate of daily cases
0.2
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

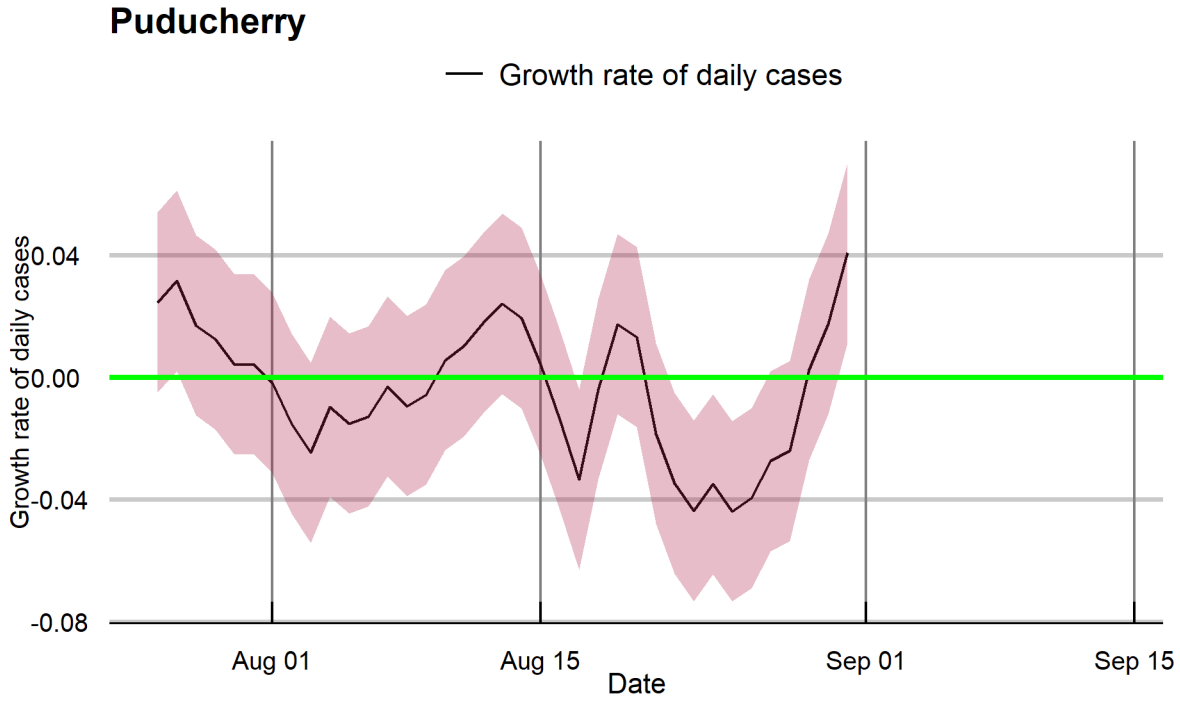

Nagaland
Data
Forecast
New cases
Forecast
Trend
150
100
50
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

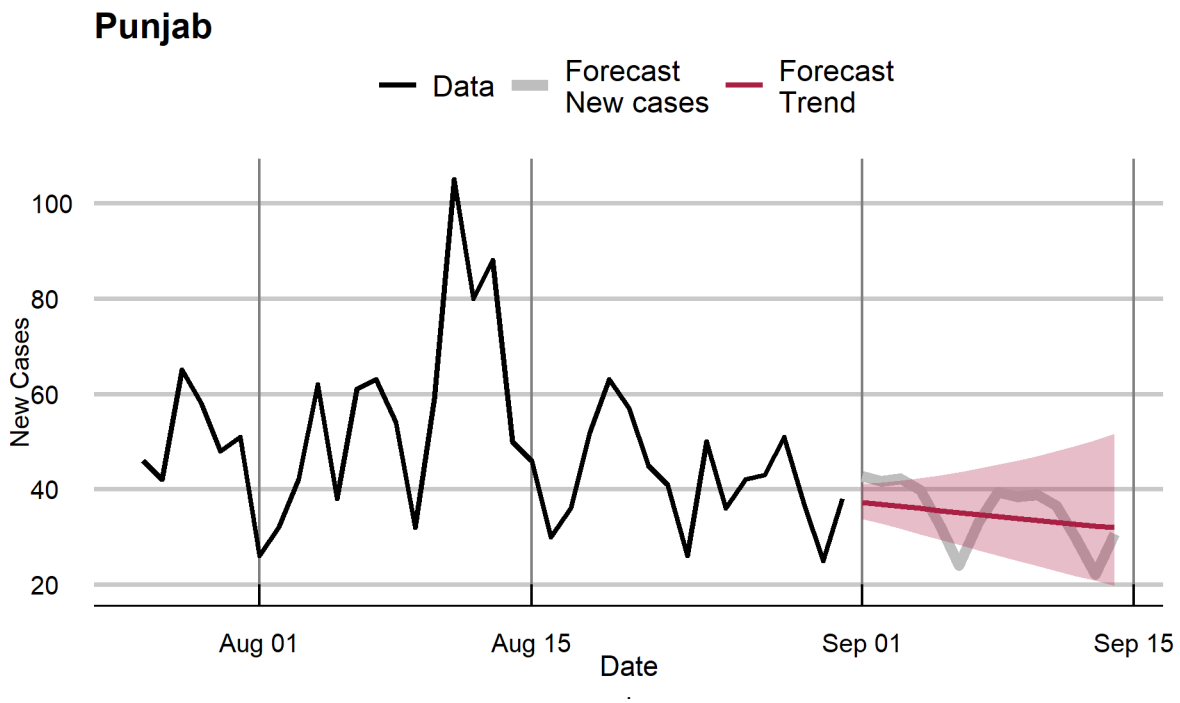

Nagaland
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

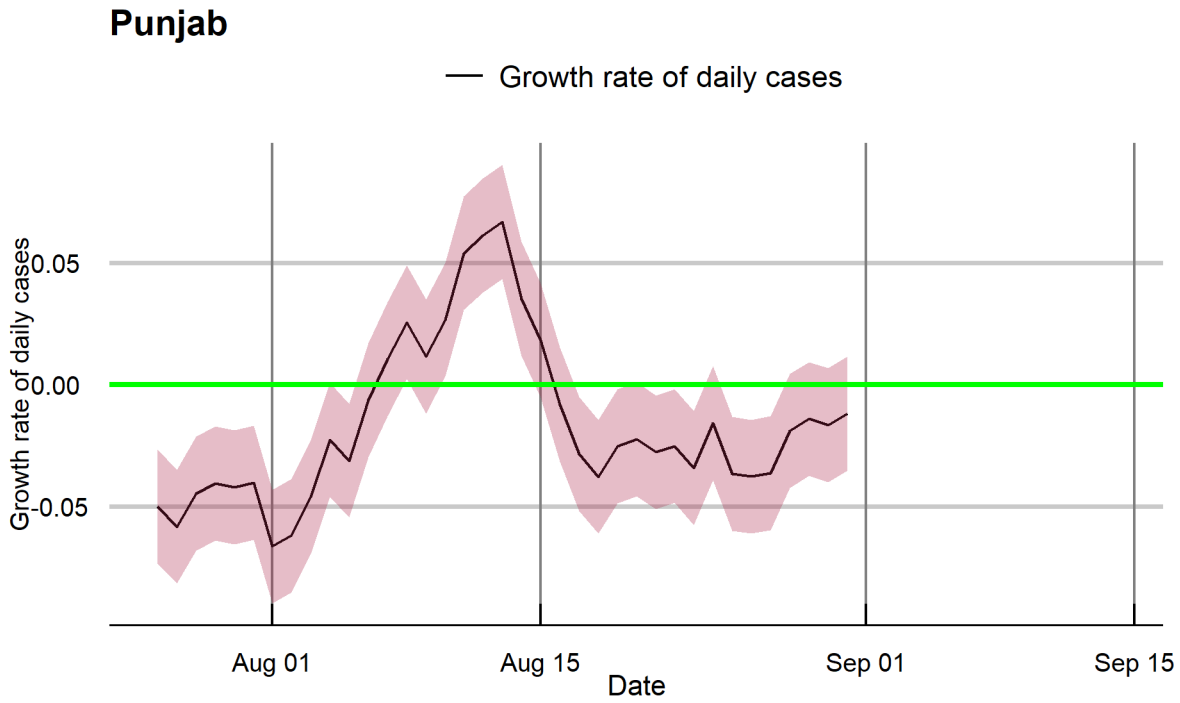

Odisha
Data
Forecast
New cases
Forecast
Trend
1,500
1,200
900
600
300
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

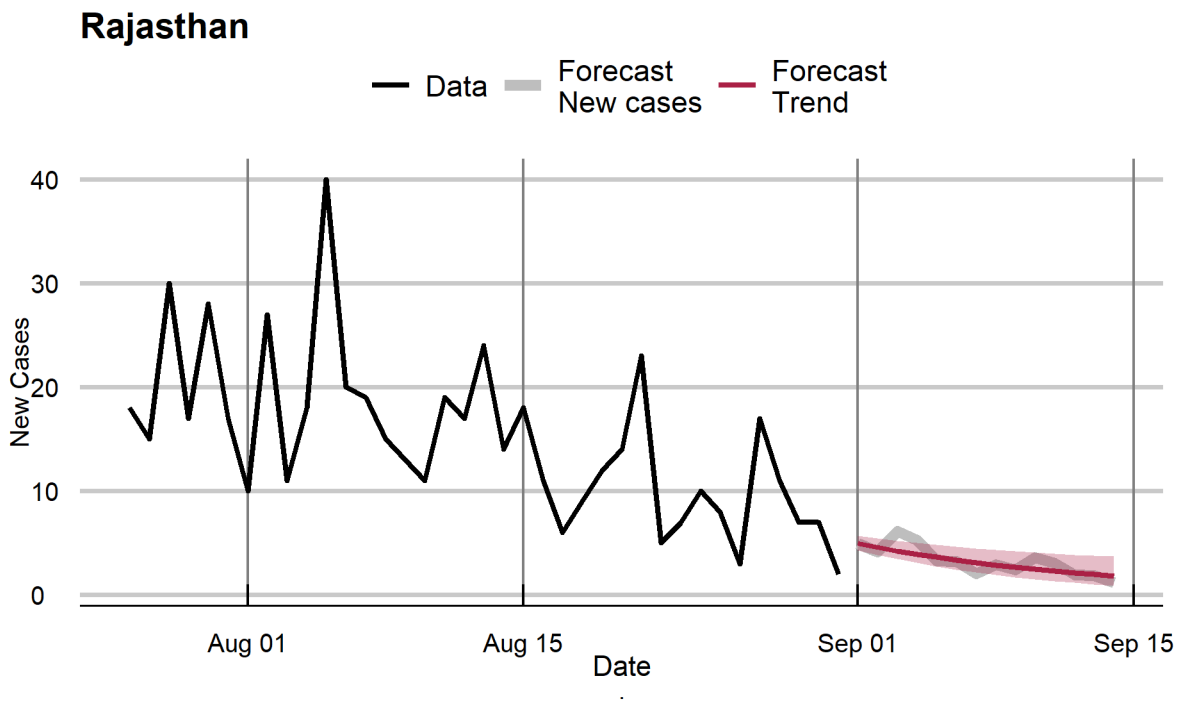

Odisha
Growth rate of daily cases
0.00
-0.02
-0.04
-0.06
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

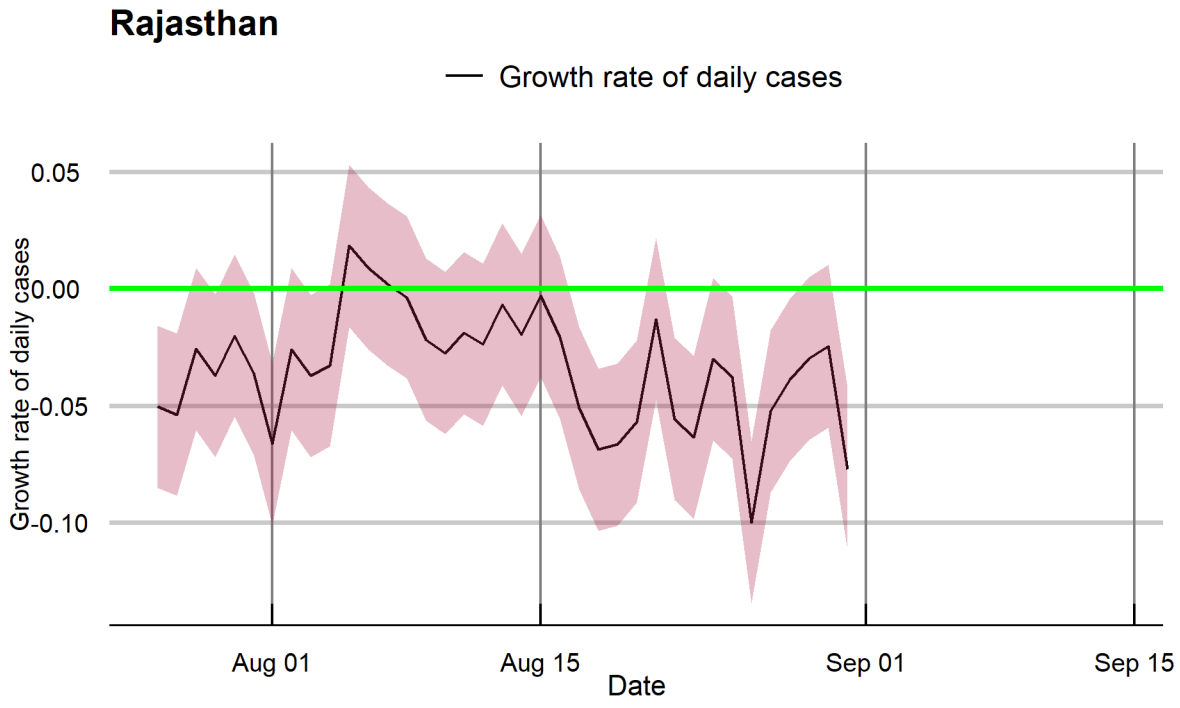

Puducherry
Data
Forecast New cases
Forecast Trend
300
200
100
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

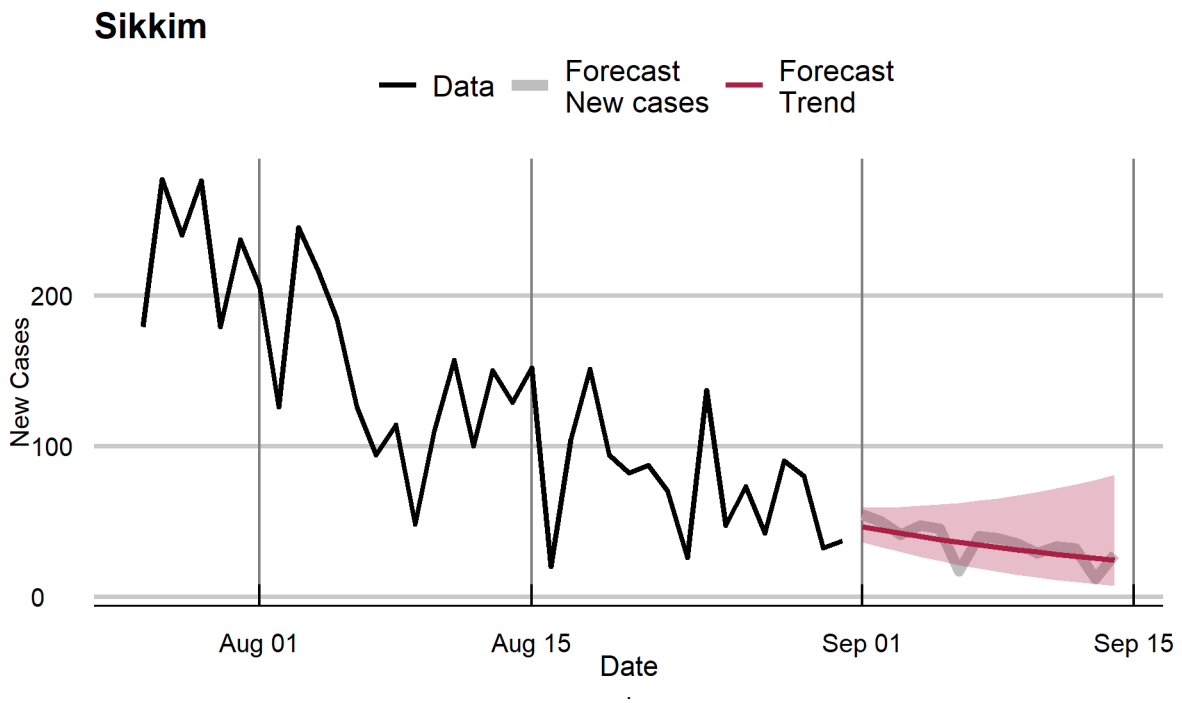

Puducherry
Growth rate of daily cases
0.04
0.00
-0.04
-0.08
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

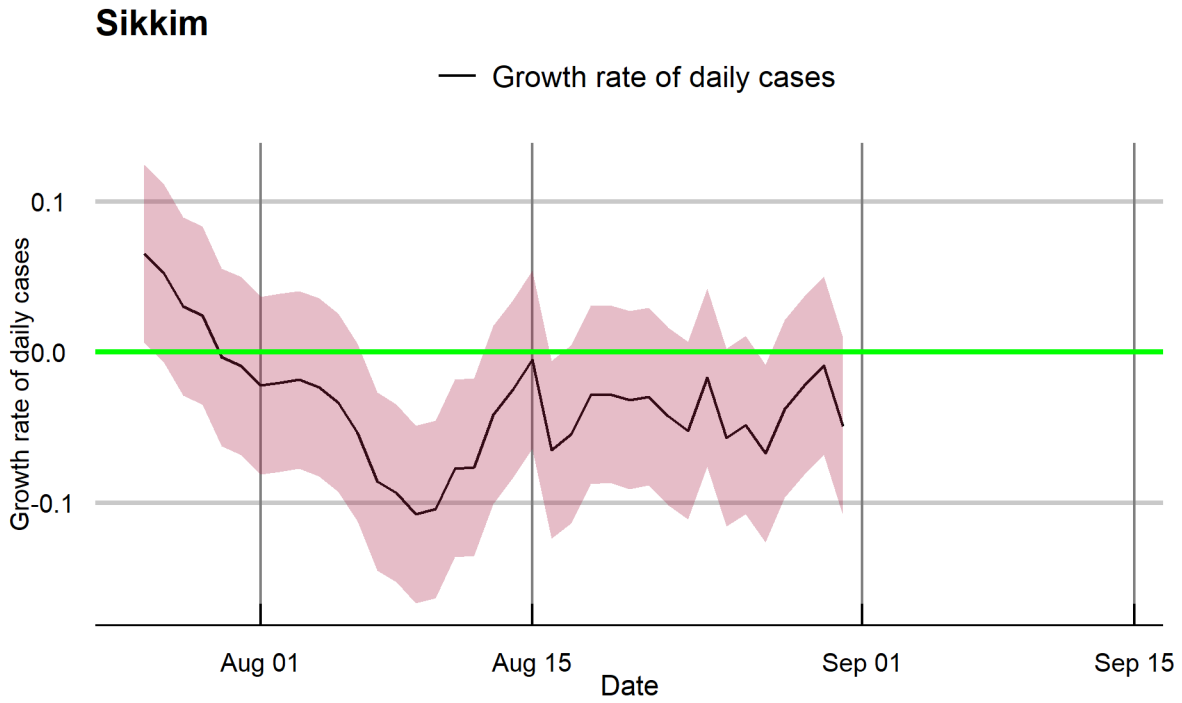

Punjab
Data
Forecast
New cases
Forecast
Trend
100
80
60
40
20
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

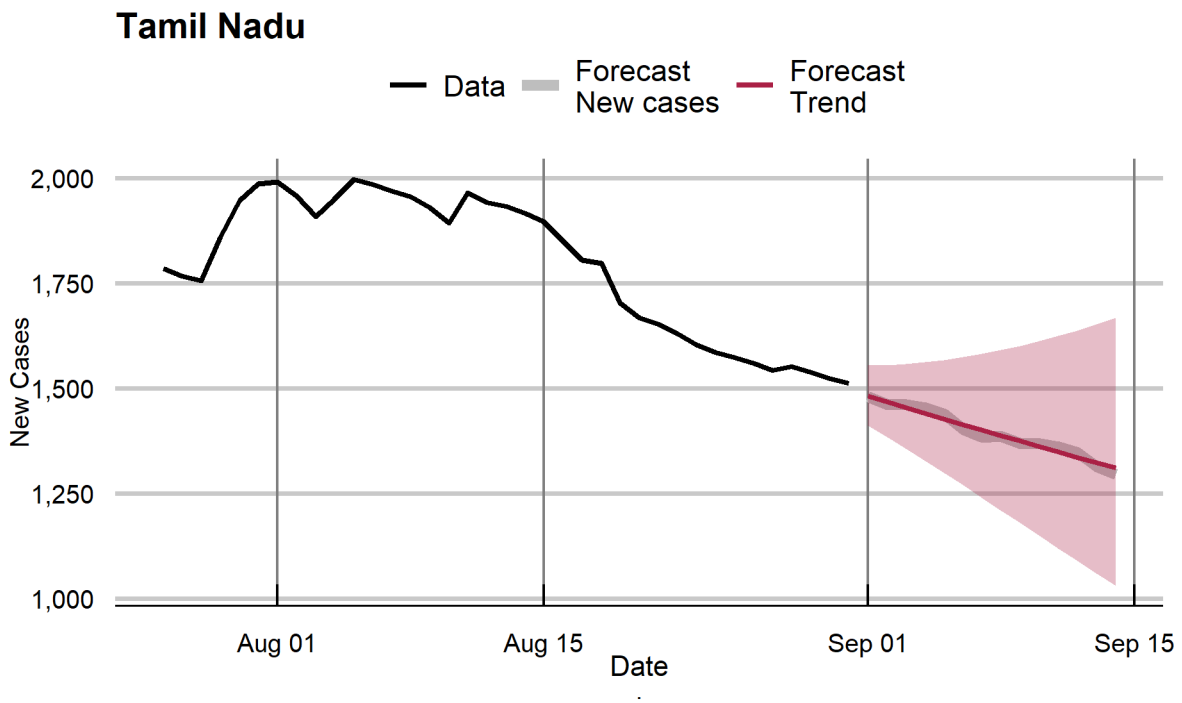

Punjab
Growth rate of daily cases
0.05
0.00
-0.05
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

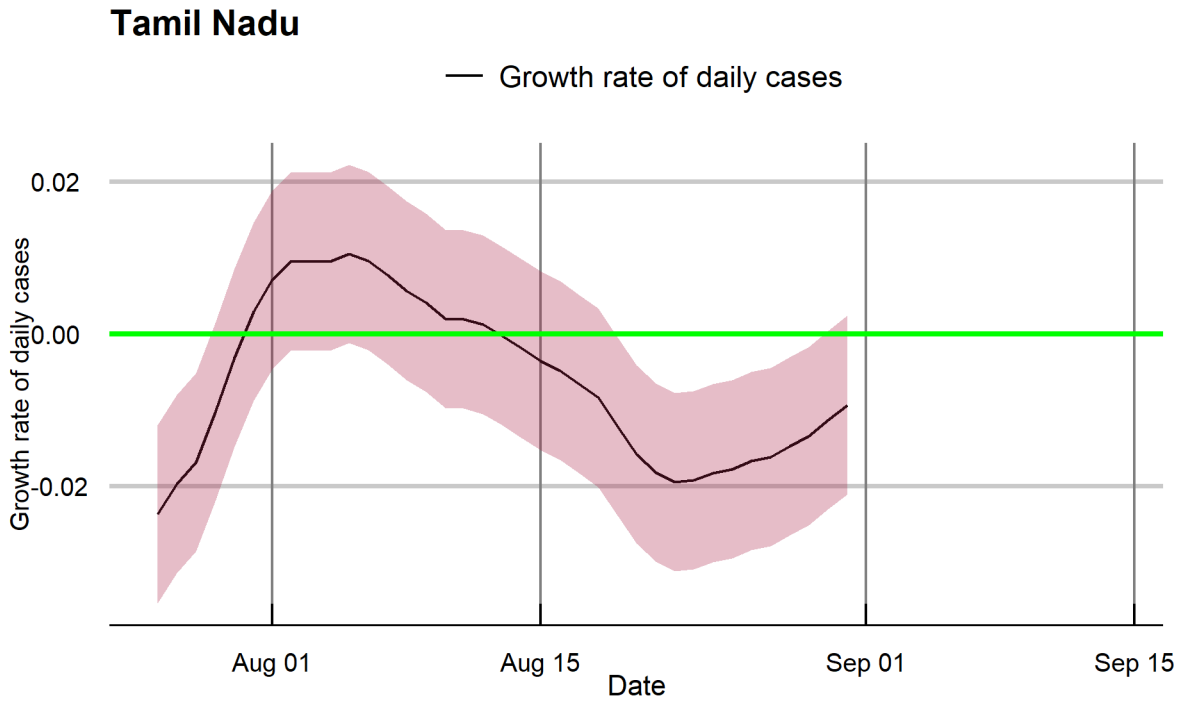

Rajasthan
Data
Forecast
New cases
Forecast
Trend
40
30
20
10
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

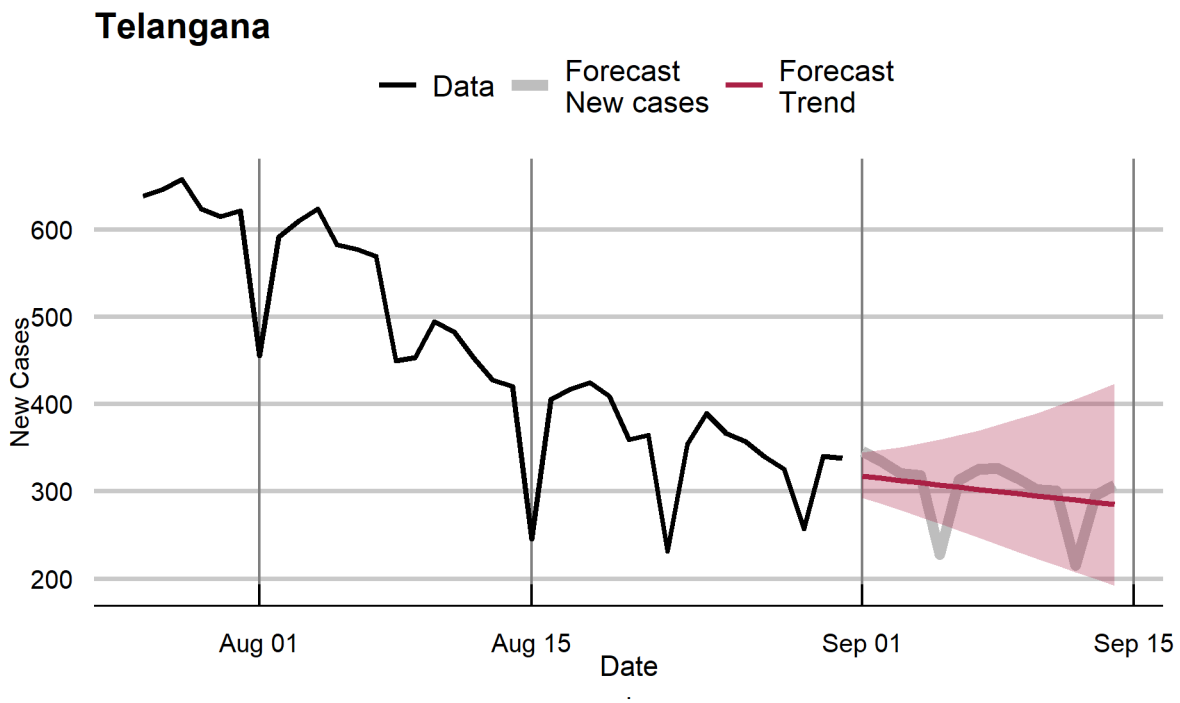

Rajasthan
Growth rate of daily cases
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

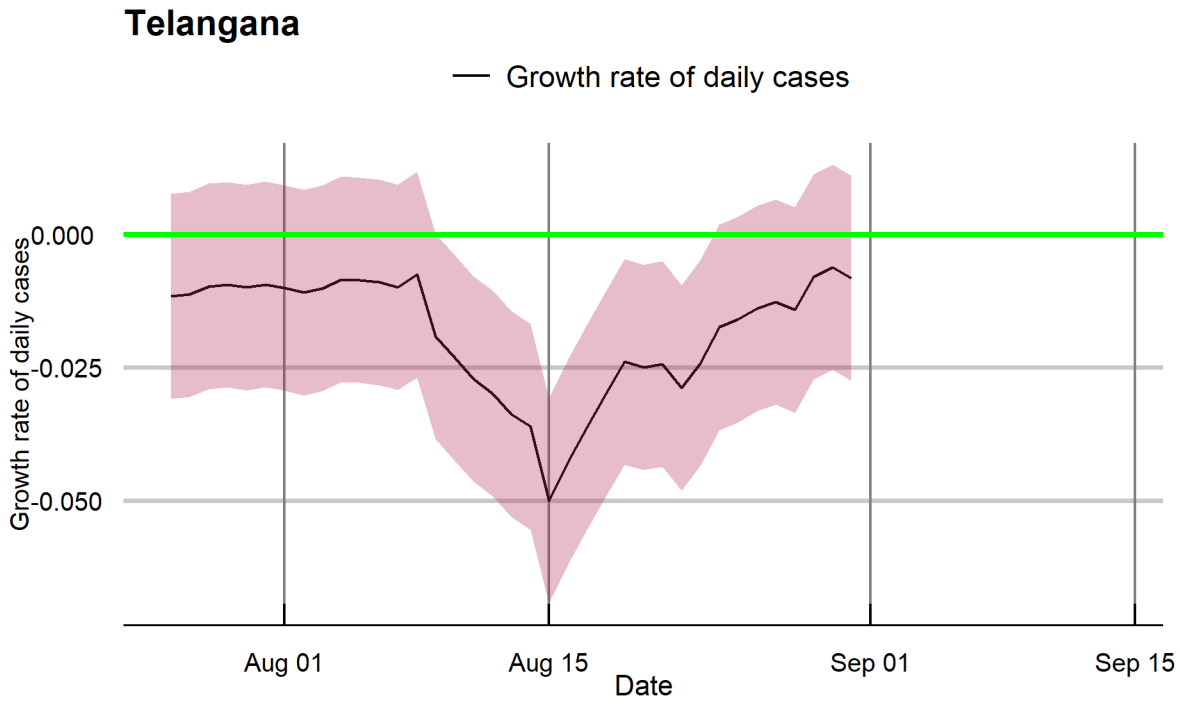

Sikkim
Data
Forecast
New cases
Forecast
Trend
New Cases
200
100
0
Aug 01
Aug 15
Sep 01
Sep 15
Date

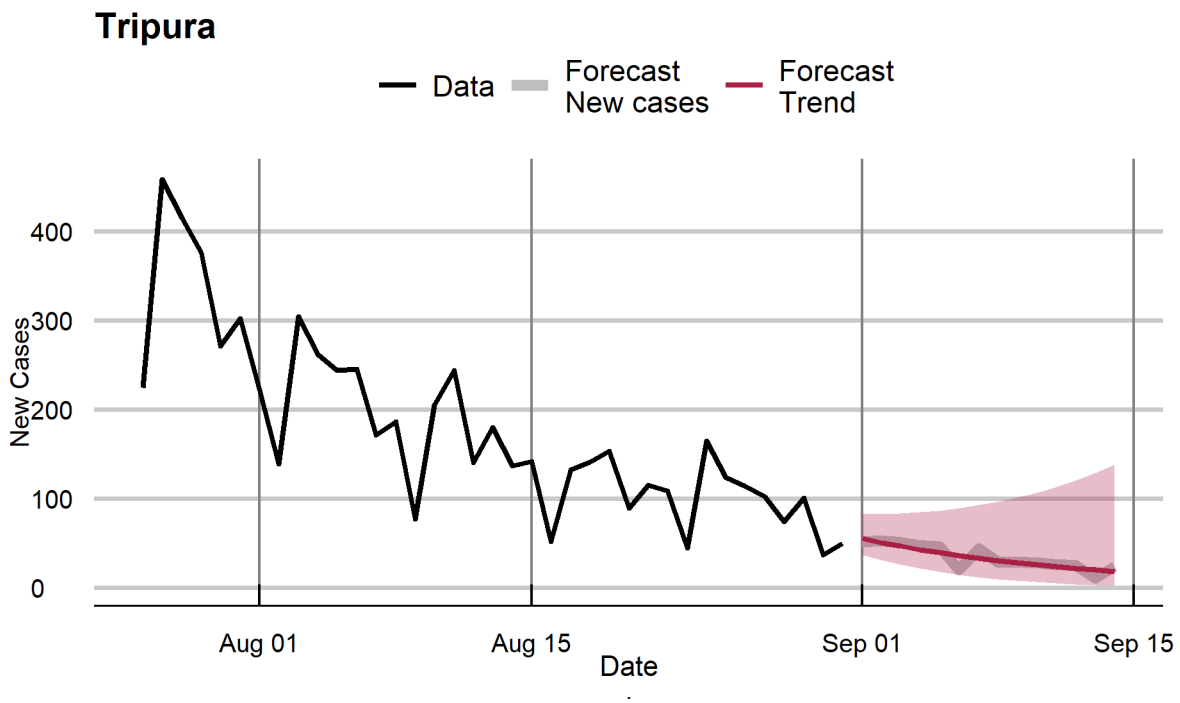

Sikkim
Growth rate of daily cases
Growth rate of daily cases
0.1
0.0
-0.1
Aug 01
Aug 15
Sep 01
Sep 15
Date

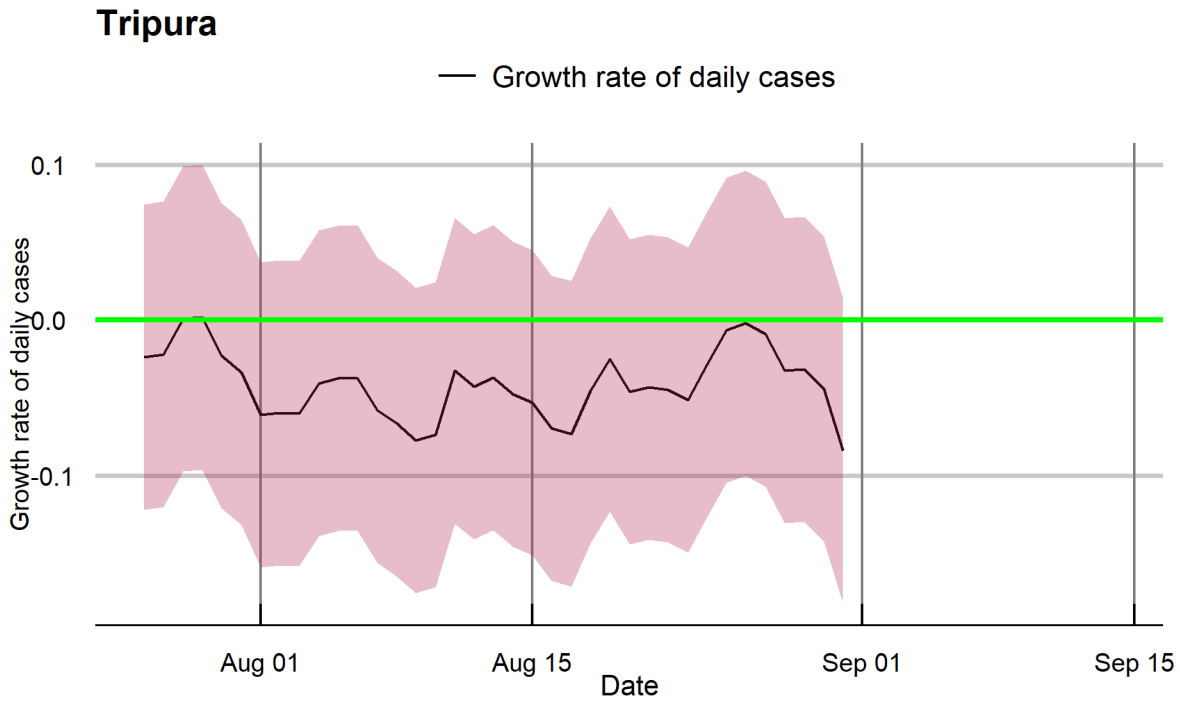

Tamil Nadu
Data
Forecast
New cases
Forecast
Trend
2,000
1,750
1,500
1,250
1,000
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

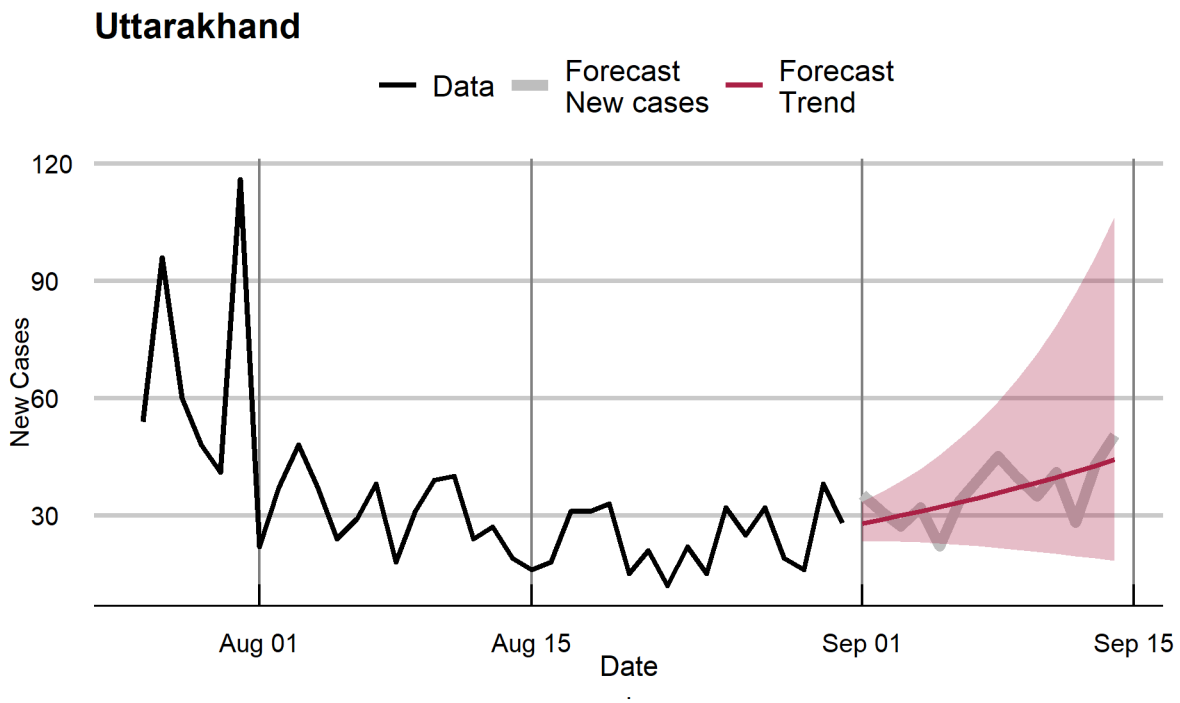

Tamil Nadu
Growth rate of daily cases
0.02
0.00
-0.02
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

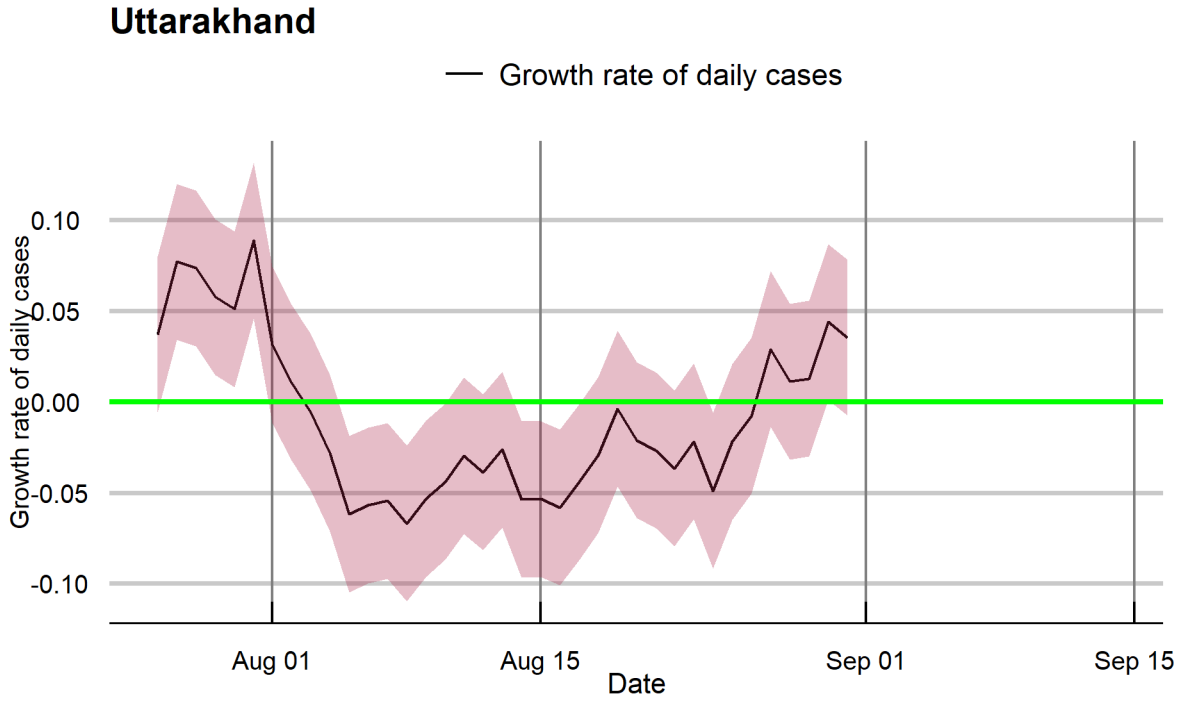

Telangana
Data
Forecast
New cases
Forecast
Trend
600
500
400
300
200
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

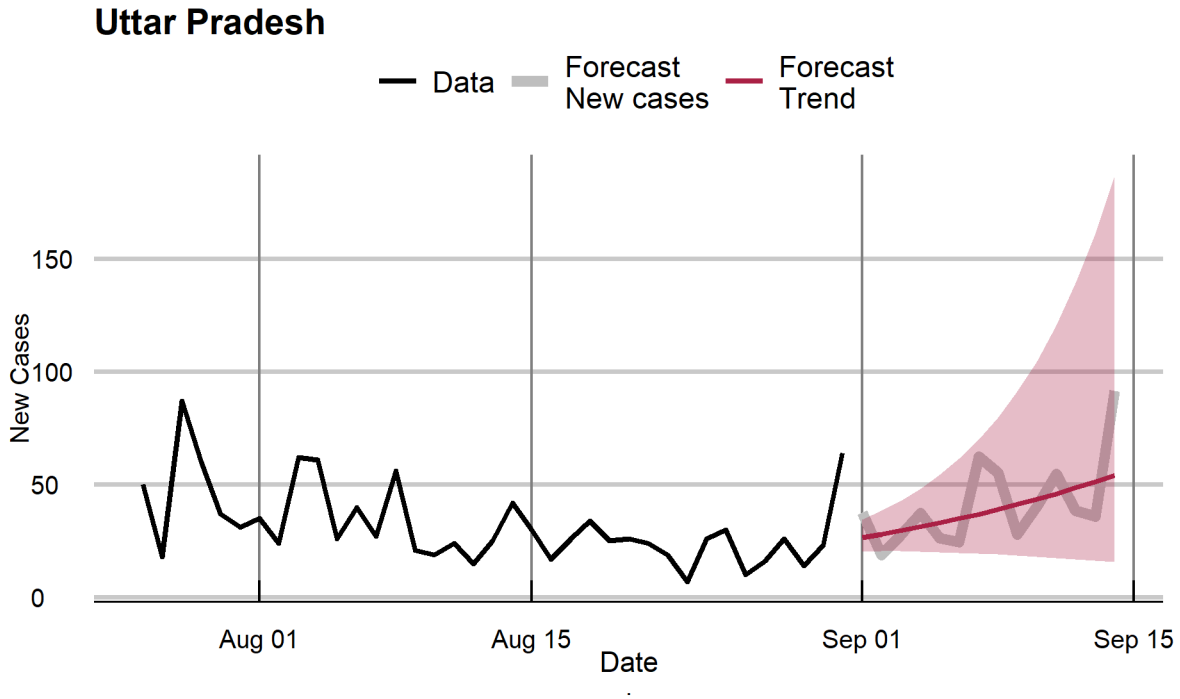

Telangana
Growth rate of daily cases
0.000
-0.025
-0.050
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

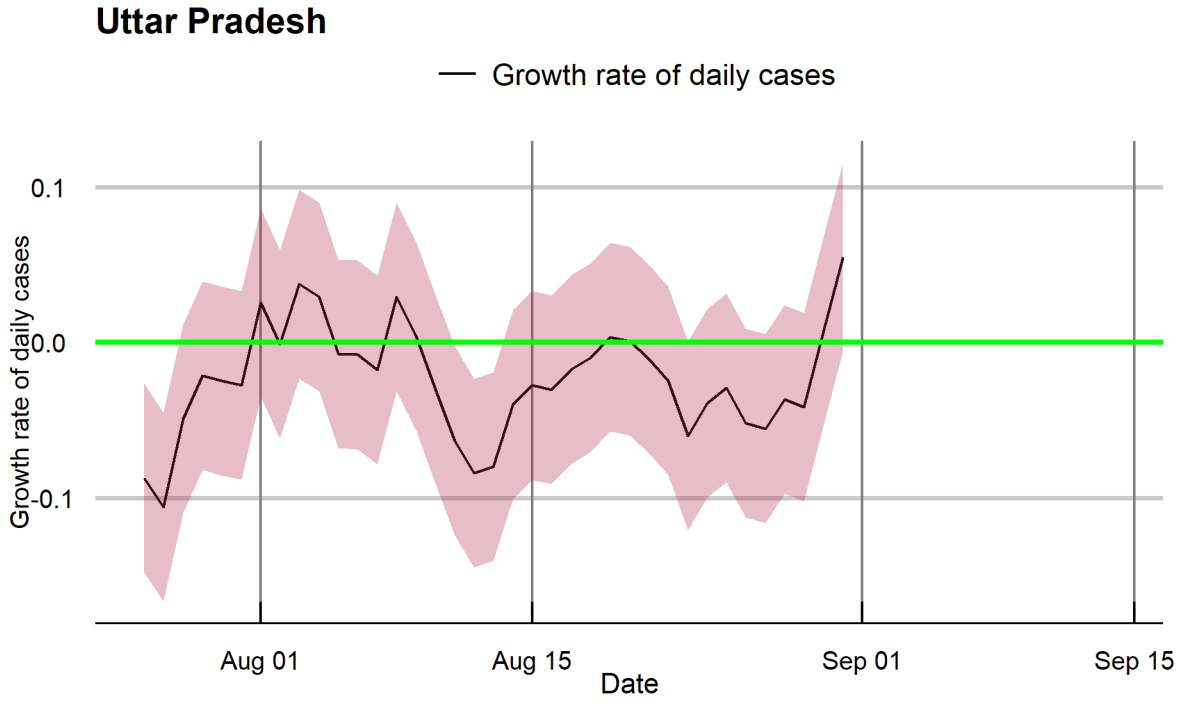

Tripura
Data
Forecast
New cases
Forecast
Trend
400
300
200
100
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

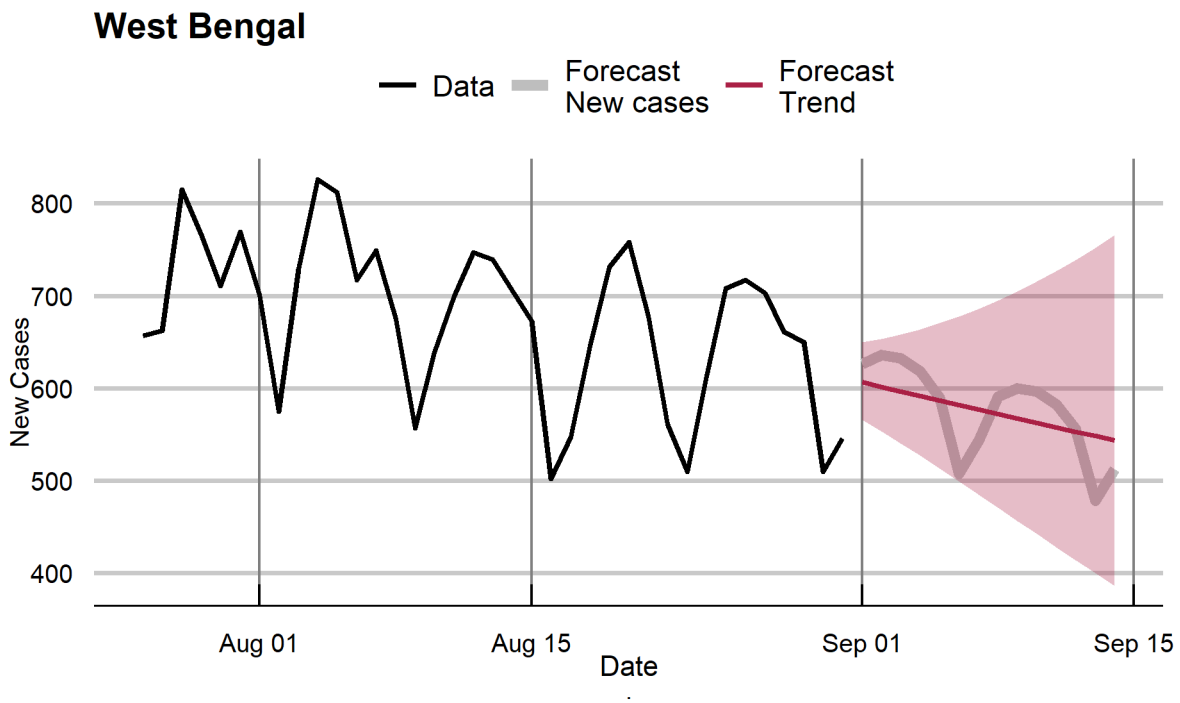

Tripura
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

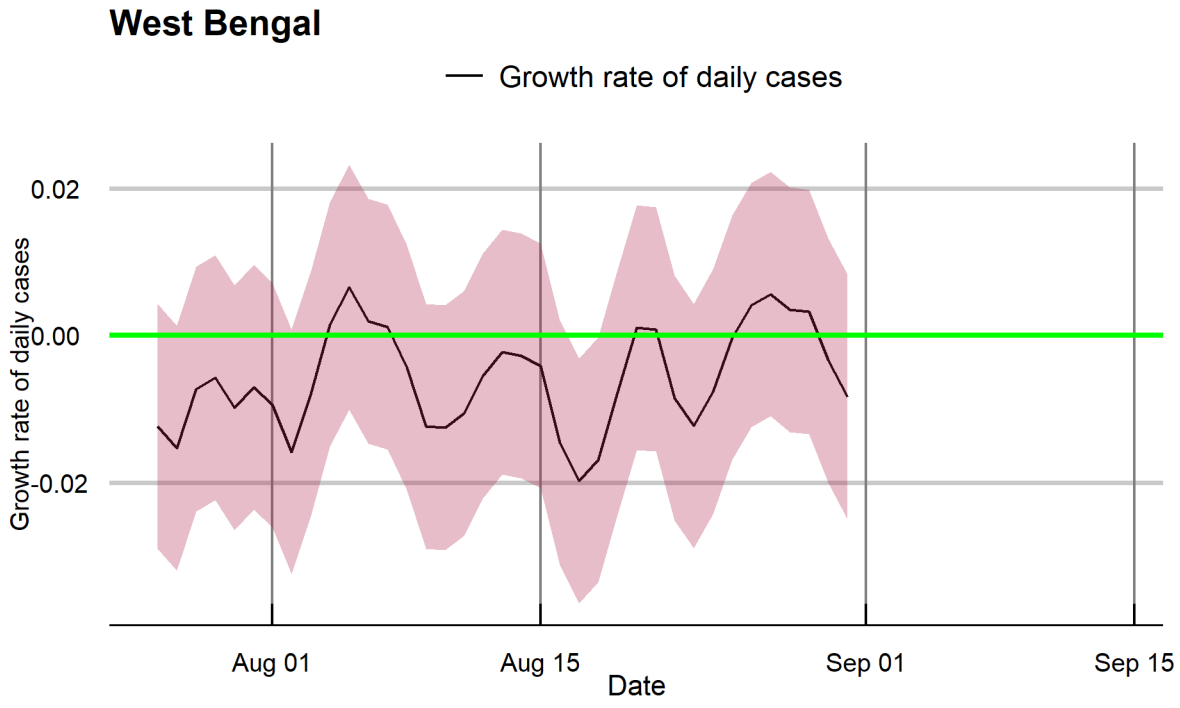

Uttarakhand
Data
Forecast
New cases
Forecast
Trend
120
90
60
30
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date


Uttarakhand
Growth rate of daily cases
0.10
0.05
0.00
-0.05
-0.10
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

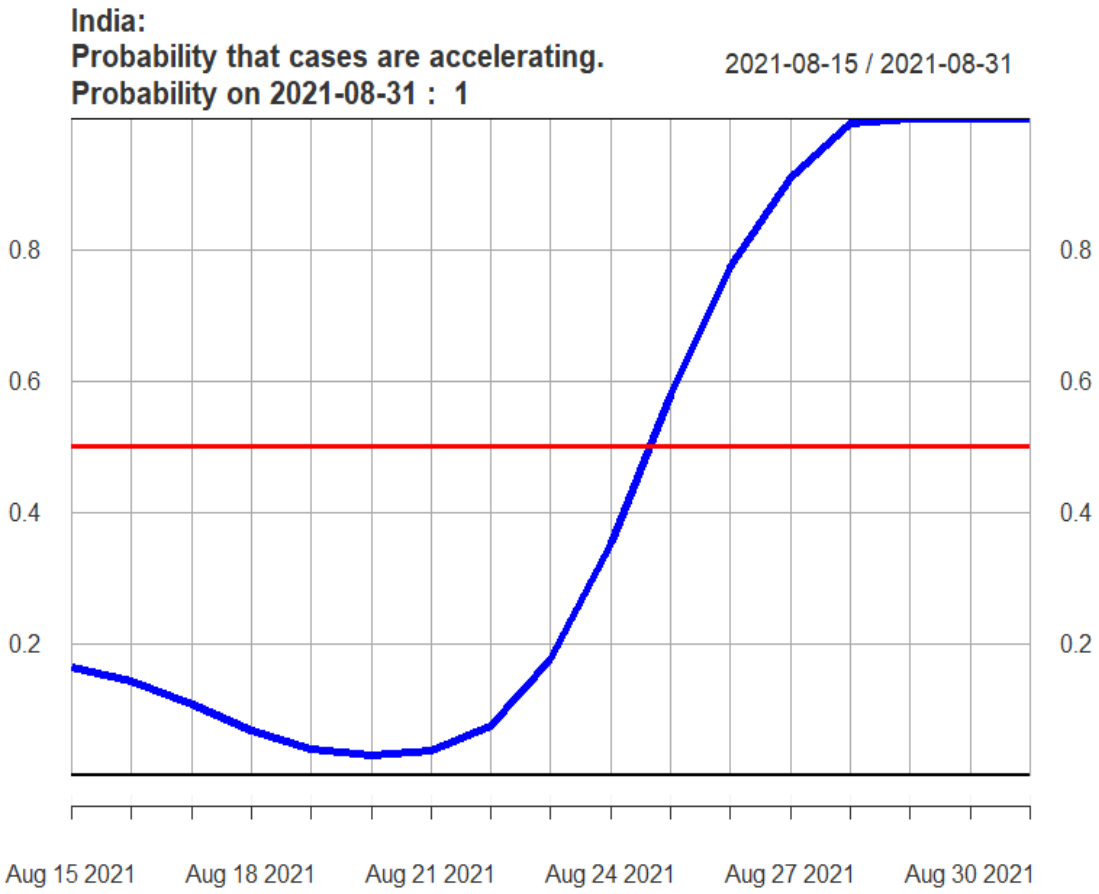

Uttar Pradesh
Data
Forecast
New cases
Forecast
Trend
150
100
50
0
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

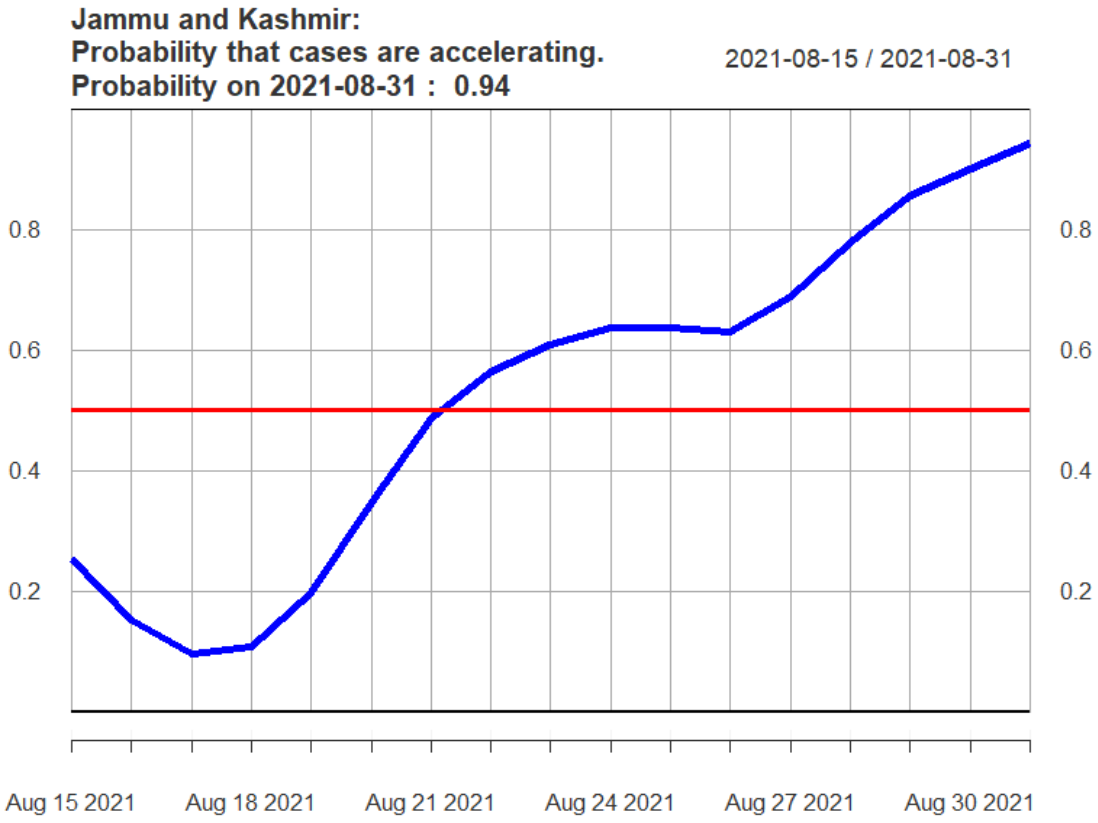

Uttar Pradesh
Growth rate of daily cases
0.1
0.0
-0.1
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

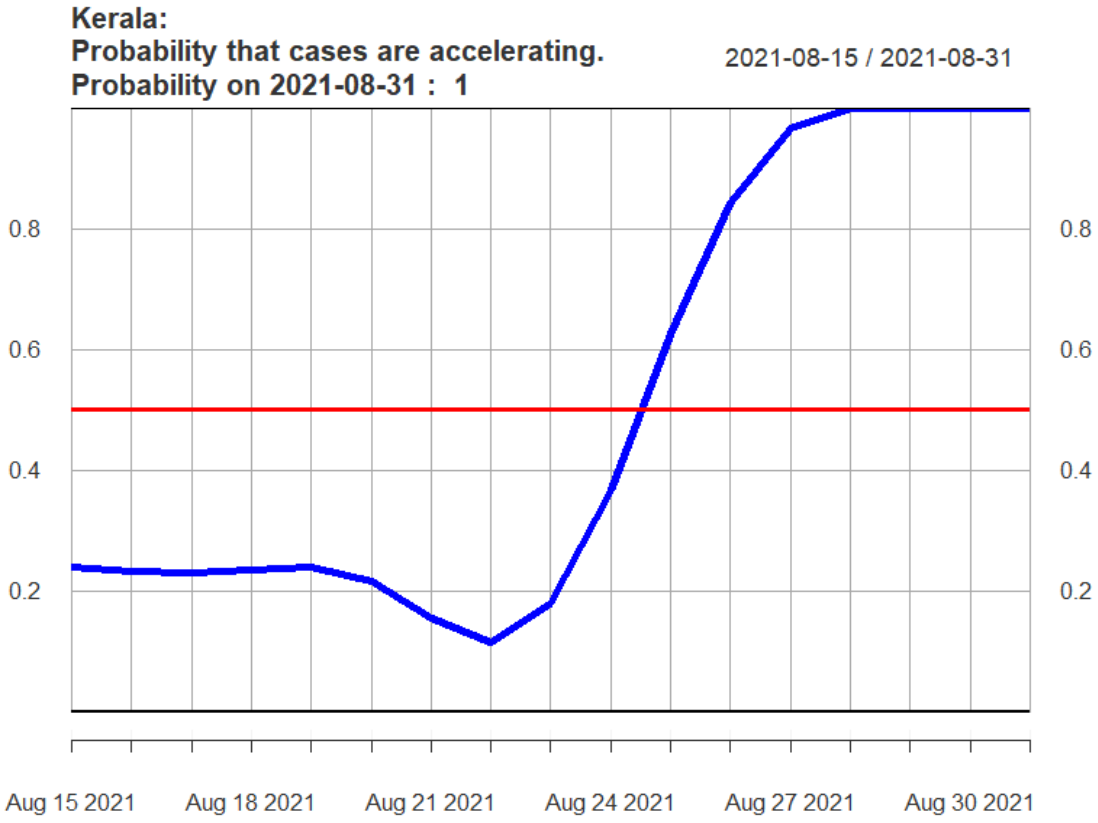

West Bengal
Data
Forecast
New cases
Forecast
Trend
800
700
600
500
400
New Cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

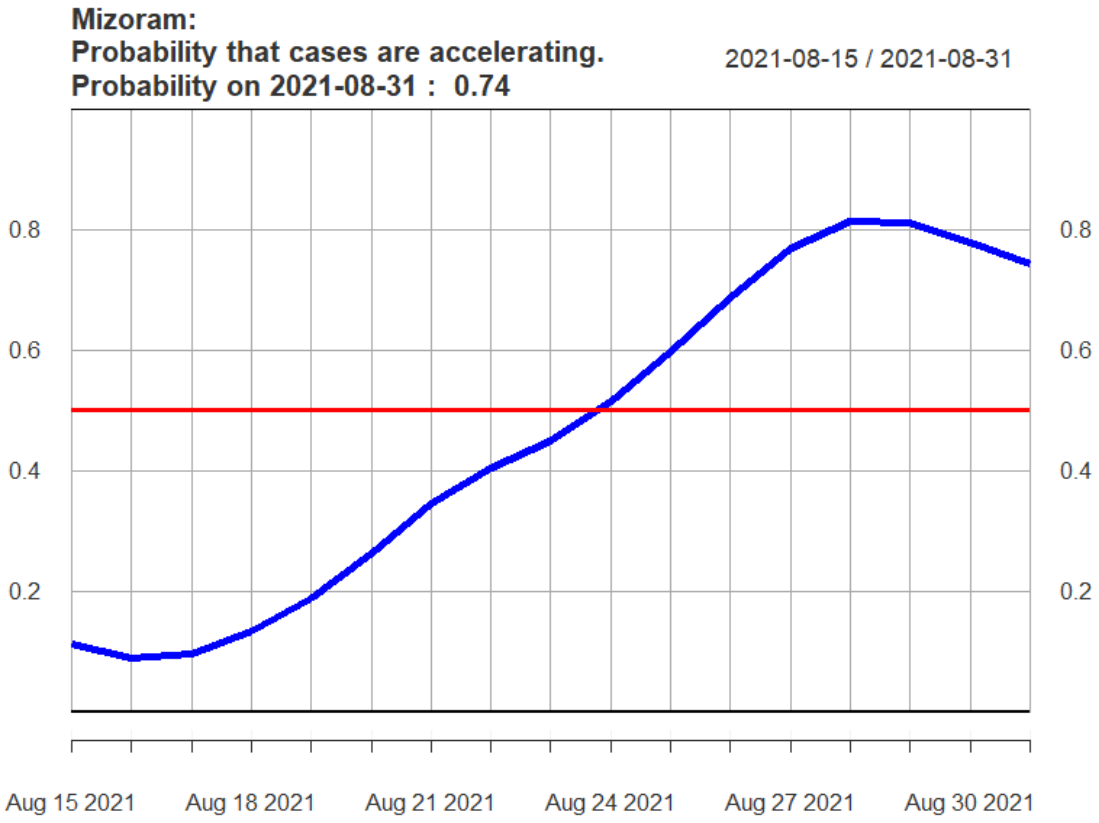

West Bengal
Growth rate of daily cases
0.02
0.00
-0.02
Growth rate of daily cases
Aug 01
Aug 15
Sep 01
Sep 15
Date

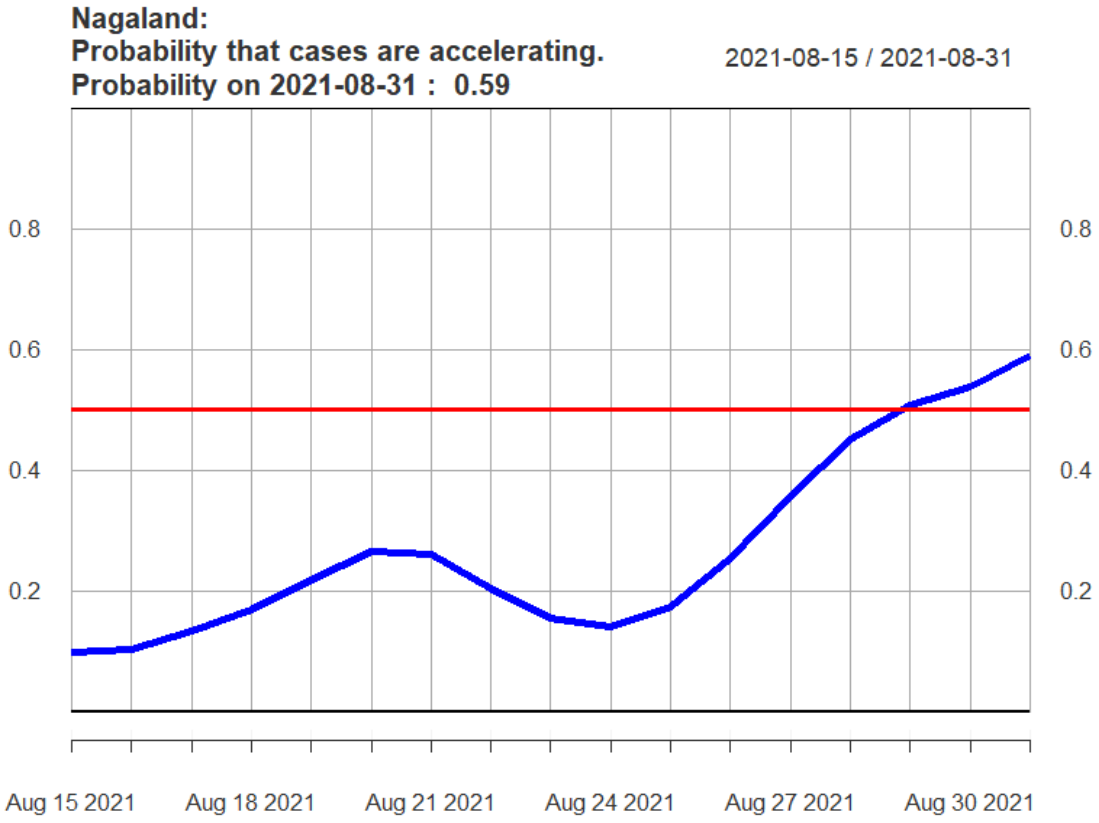
The nature of growth in new cases:



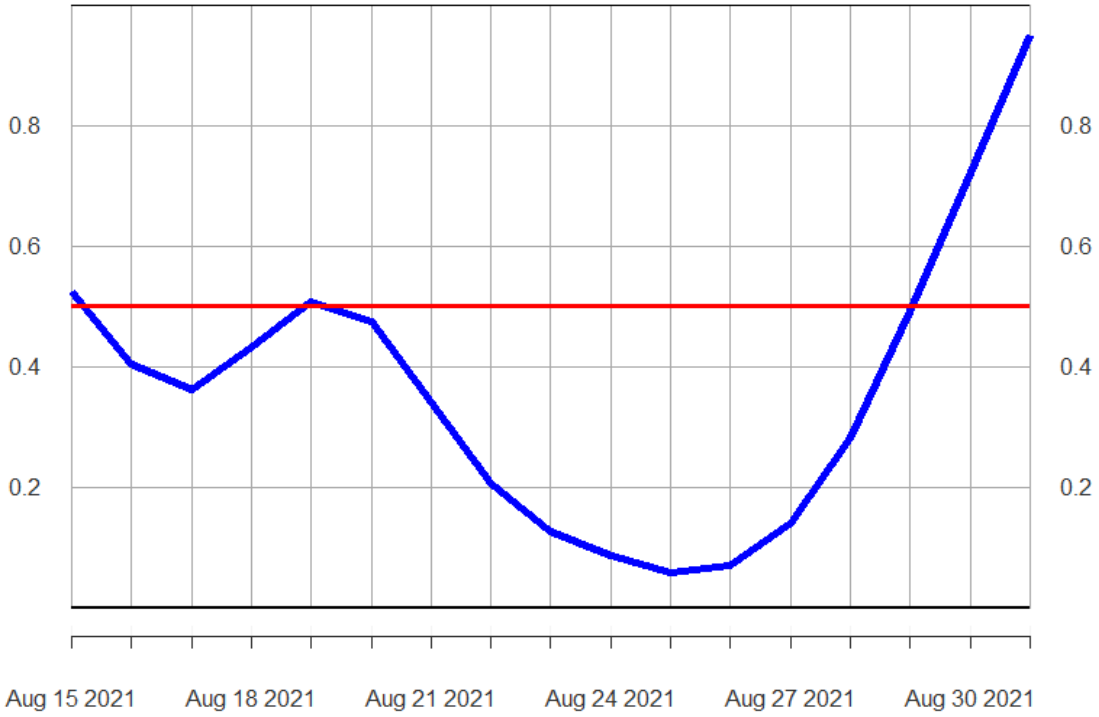

Jammu and Kashmir:
Probability that cases are accelerating.
Probability on 2021-08-31 : 0.94
2021-08-15 / 2021-08-31
0.8
0.6
0.4
0.2
Aug 15 2021
Aug 18 2021
Aug 21 2021
Aug 24 2021
Aug 27 2021
Aug 30 2021


Kerala:
Probability that cases are accelerating.
Probability on 2021-08-31 : 1
2021-08-15 / 2021-08-31
0.8
0.6
0.4
0.2
Aug 15 2021
Aug 18 2021
Aug 21 2021
Aug 24 2021
Aug 27 2021
Aug 30 2021

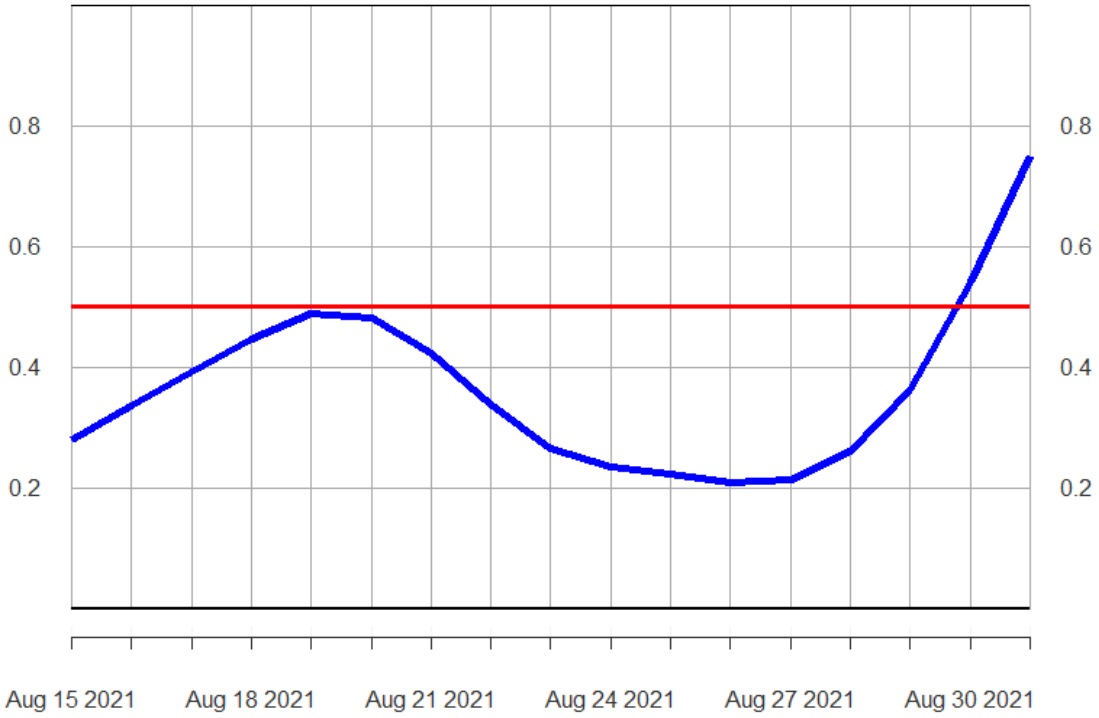

Mizoram:
Probability that cases are accelerating.
Probability on 2021-08-31 : 0.74
2021-08-15 / 2021-08-31
0.8
0.6
0.4
0.2
Aug 15 2021
Aug 18 2021
Aug 21 2021
Aug 24 2021
Aug 27 2021
Aug 30 2021

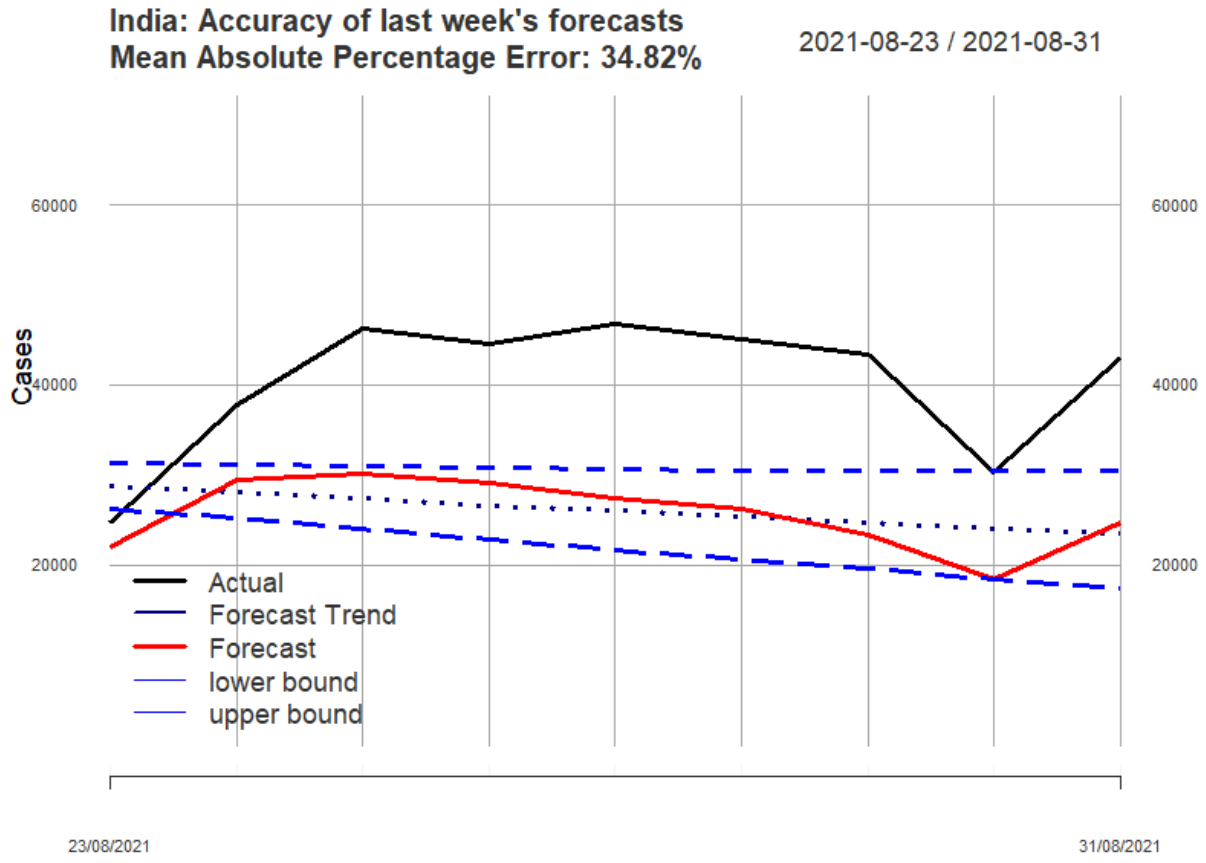

Nagaland:
Probability that cases are accelerating.
Probability on 2021-08-31 : 0.59
2021-08-15 / 2021-08-31
0.8
0.6
0.4
0.2
Aug 15 2021
Aug 18 2021
Aug 21 2021
Aug 24 2021
Aug 27 2021
Aug 30 2021

Puducherry:
Probability that cases are accelerating. 2021-08-15 / 2021-08-31
Probability on 2021-08-31 : 0.95



Uttar Pradesh:
Probability that cases are accelerating. 2021-08-15 / 2021-08-31
Probability on 2021-08-31 : 0.75





Note: Actual cases over 23-31 August was consistently and significantly higher than predictions for that period based on data till 22 August. This is due to surge in cases in Kerala following Onam festival.

Notes

Data: COVID-19 confirmed cases and deaths data are sourced from COVID19-India API: https://api.covid19india.org/

New cases: forecasts. Forecasts above are based on a structural time series model that uses all the data in estimation but adapts to the trend emerging in the most recent period.

The method is described in: Harvey, A. and P. Kattuman (2020). Time series models based on growth curves with applications to forecasting coronavirus. *Harvard Data Science Review*, Special issue 1 - COVID -19. https://hdsr.mitpress.mit.edu/pub/ozgjx0yn/release/2 , and Harvey, A., P. Kattuman, and C. Thamotheram (2021). Tracking the mutant: forecasting and nowcasting COVID-19 in the UK in 2021. *National Institute Economic Review*. 256, 110-126. doi:10.1017/nie.2021.12.

Forecast accuracy: is assessed using mean absolute percentage error of the forecasts of cases over the past week. Forecast accuracy will in general be lower for the smaller states / union territories. It is important to pay attention to the confidence intervals around the forecasts. The coverage of the confidence intervals presented is 68%, implying there is 16% probability of the upper bound being exceeded.

New cases: growth rate. The filtered trends presented for daily growth rates of cases are estimated using the Kalman filter, applied to the observed series. The method filters out day of the week effects and random noise to reveal the underlying signal. Unlike methods such as the moving average, this method adapts the trend to changes in real time and characterises underlying patterns of surges or attenuations that are hidden in the volatile series. The method is described in the papers listed above.

***R*:** The *R*-estimates are based on the nowcast of the growth rate; the estimation approach is described in Harvey, A. and P. Kattuman (2021). A farewell to R: Time series models for tracking and forecasting epidemics. *Journal of the Royal Society Interface* (forthcoming). The confidence interval is based on one standard deviation, with coverage of 68%.

Probability The probability that the growth of new cases is increasing at an increasing rate is extracted from the statistical model. The pandemic phase is of extreme concern when this probability exceeds 0.5.

Note: The accuracy of forecasts rely on the quality of the published data. Further, changes in government pandemic policies and in transmission relevant social behaviour may lead realised numbers to deviate from forecasts.

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